

# Metal Progress



October 1956



## Surface zoned gas carburizing toughens gears, cuts steel costs

The manufacturer of these heavy duty truck gears improved metallurgical properties and reduced material and labor costs when he adopted Surface zoned gas carburizing. Unique atmosphere manifolding enables him to limit surface carbon content (80% max.), get sufficient case depth, and still maintain good carburizing rates (530-900 net lbs./hr.). With the quality of Surface carburizing, he could use steels lower in alloy content.

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# Metal Progress

Volume 70, No. 4

October . . . 1956

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ERNEST E. THUM, Editor  
FLOYD E. CRAIG, Art Director

MARJORIE R. HYSLOP  
Managing Editor

HAROLD J. ROAST, E. C. WRIGHT and J. L. MCCLOUD, *Consulting Editors*

Cover shows a scene in the huge new ferro-alloy plant of Electro Metallurgical Co. at Marietta, Ohio.

- Ferrosilicon Manufacture at Marietta**, by E. E. Thum . . . . . 65  
Ferrosilicon is only one of many electric furnace products made at the Marietta Works of Electro Metallurgical Co., a Division of Union Carbide and Carbon Corp. Equipment and operations are quite different from those in conventional iron and steel works, as this detailed description will indicate. (C 21, Si, Fe-n) \*
- A New Composition for Fast Malleable**, by A. L. Boegehold . . . . . 73  
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- Finishes for Aluminum Alloys, Part I—Electrolytic or Anodic Coatings**, by Walter E. Pocock . . . 75  
Anodizing increases the corrosion resistance and improves the appearance of aluminum alloys. The various processes and the properties of the resultant coatings are described. (L 19, Al)
- Limitations to Processes Using a Metal as a Reducing Agent**, by L. M. Pidgeon . . . . . 79  
While magnesium and calcium are very useful reagents for reducing some of the "new" or reactive metals from purified chemical compounds, certain limitations are fixed by their chemical and physical properties—notably, the free energy of formation of their slag reaction products, their melting and boiling points, and their tendency to alloy with the desired metal as it is produced. (C 26, T 5, Mg, Ca)
- Selection of Heat Treating Process and Equipment**, by E. J. Pavesic and R. T. Sinnott . . . . . 83  
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- Expendable Molds for Titanium Castings**, by A. L. Feild, Jr. . . . . 92  
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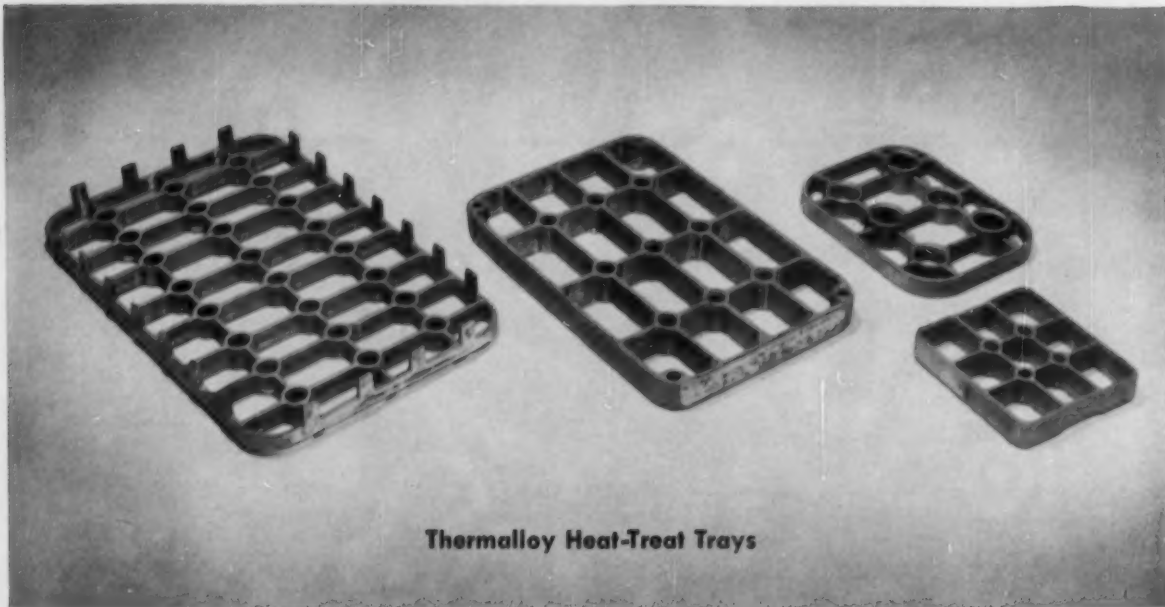
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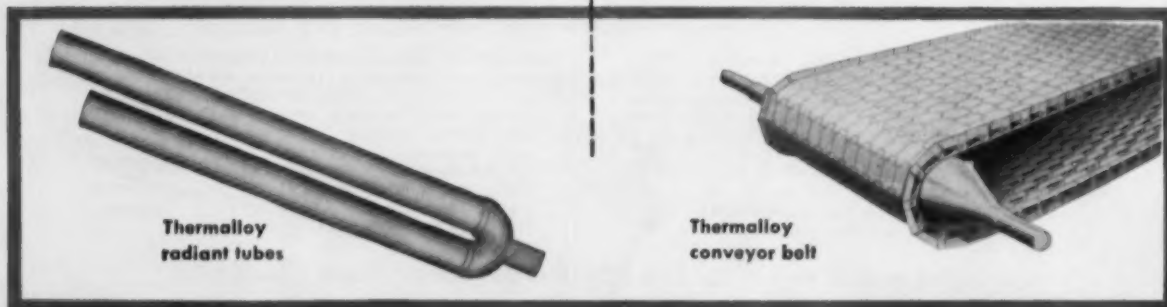
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## As I was saying...



THESE ARE the most exciting and interesting times that have come my way in a long, long con. Plans for increased activity and continued progress for the A.S.M. keep rolling, rolling right up to the open front door. Here are a few: Your Board of Trustees has selected a 100-acre plot of beautiful rolling countryside, not too far from Cleveland, to be the future home of the A.S.M. of Tomorrow. They interviewed some of the top architectural firms of the United States who were recommended by the deans of two architectural schools and finally unanimously selected Skidmore, Owings and Merrill of New York and Chicago. This firm is already on the job making studies of the A.S.M. requirements for today and tomorrow. This one fact we learned — it requires about one year from the time the architect is hired

before the contractor can start construction. Counting one year for building, occupancy is two years away. So we'll have to mark time.

The Board came to headquarters on Aug. 30 and 31 for a two-day meeting and to take care of such necessary activities as closing the books for the fiscal year (Aug. 31) and making appropriations for the coming year. The newly nominated and elected (July 15) officers attended this meeting since many actions concerned the '56-'57 year. The financial reports were at the top of the agenda and these were received and accepted. They portrayed the best year in the Society's history.

Here are additional highlights: Reports on Cleveland Congress and Exposition (now history) described completed arrangements for the strongest program and largest show presented by A.S.M. Western Metal Congress (March 25 to 29, 1957) shaping up, while Western Metal Exposition was rushing headlong to a sellout. Granted chapter charters to Wilmington (Delaware) and Delaware Valley (Trenton), both fissions from Philadelphia, also San Fernando Valley (offshoot from Los Angeles). Approved many phases of report from Special Committee on Publications, such as preprinting technical papers quarterly as soon as approved by Transactions Committee; approving a new Special Engineering Program Committee to arrange program for national meetings other than technical papers. Received report of more than 200 applications from overseas conferees for Second World Metallurgical Congress (Chicago Nov. 4 to 8, 1957). Approved progress on new edition of Metals Handbook in two volumes, with first volume's 67 committees now active under increased staff of ten consultants. President-Elect Don Clark made recommendations and the Board approved the appointment of members to fill vacancies occurring on all national and other standing committees.

You'll be reading this column (if you do) after the convention is over and you'll know of the great honor conferred upon me as the recipient of the A.S.M. Gold Medal. When President Schaefer made the announcement at the Board Meeting I was emotionally distressed because I realized how unworthy I am to be so recognized. When President Ad stated that it was the wish of the chapters that I receive recognition for the years of service in behalf of the World of Metallurgy my pleasure and satisfaction knew no bounds. Mill and I both thank you for this honor — we shall cherish it always — you, my friends, have always been so kind and thoughtful — so we can truthfully say, "We love you, too."

Sincerely yours,

*Bill*

W. H. EISENMAN, Secretary  
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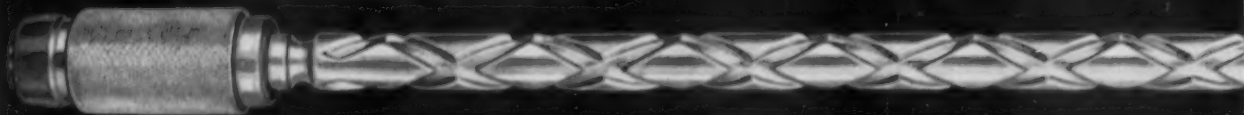
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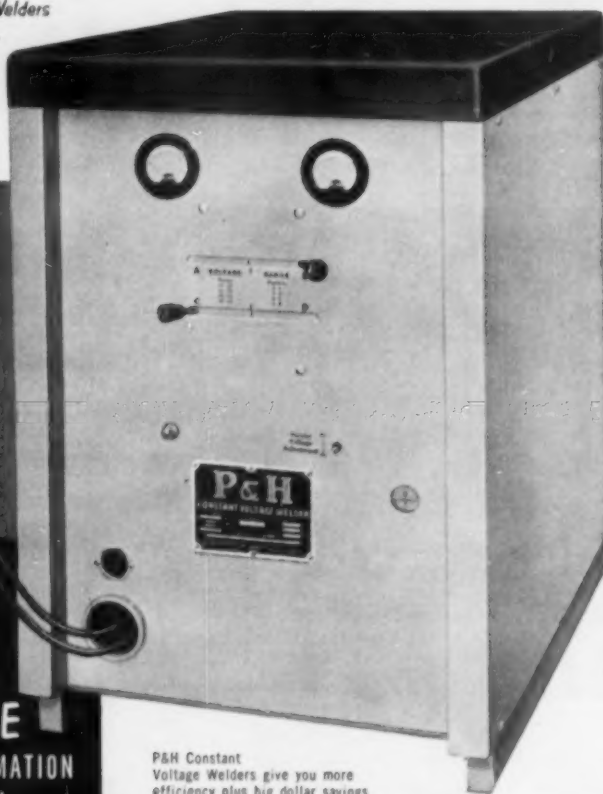
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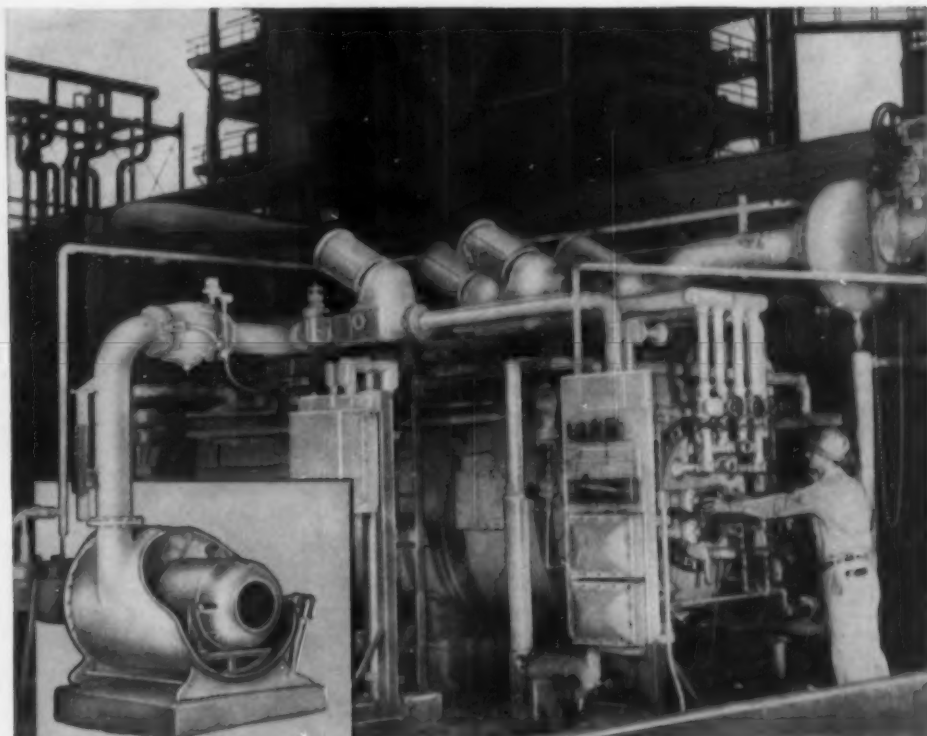
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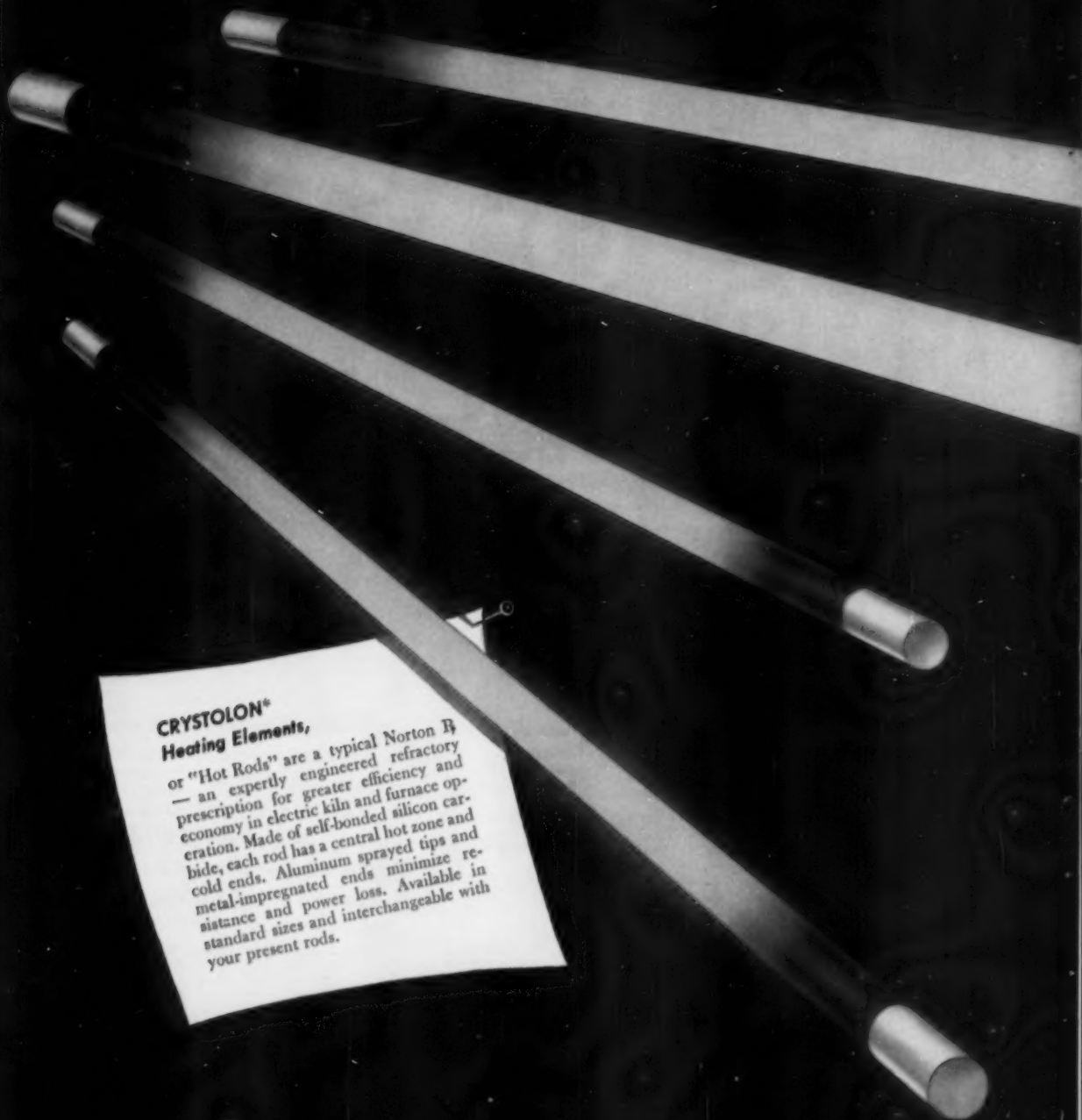


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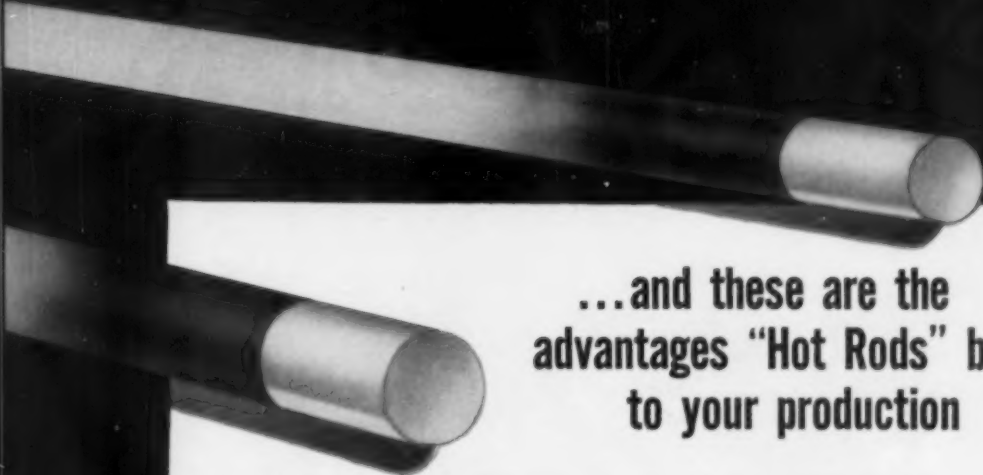
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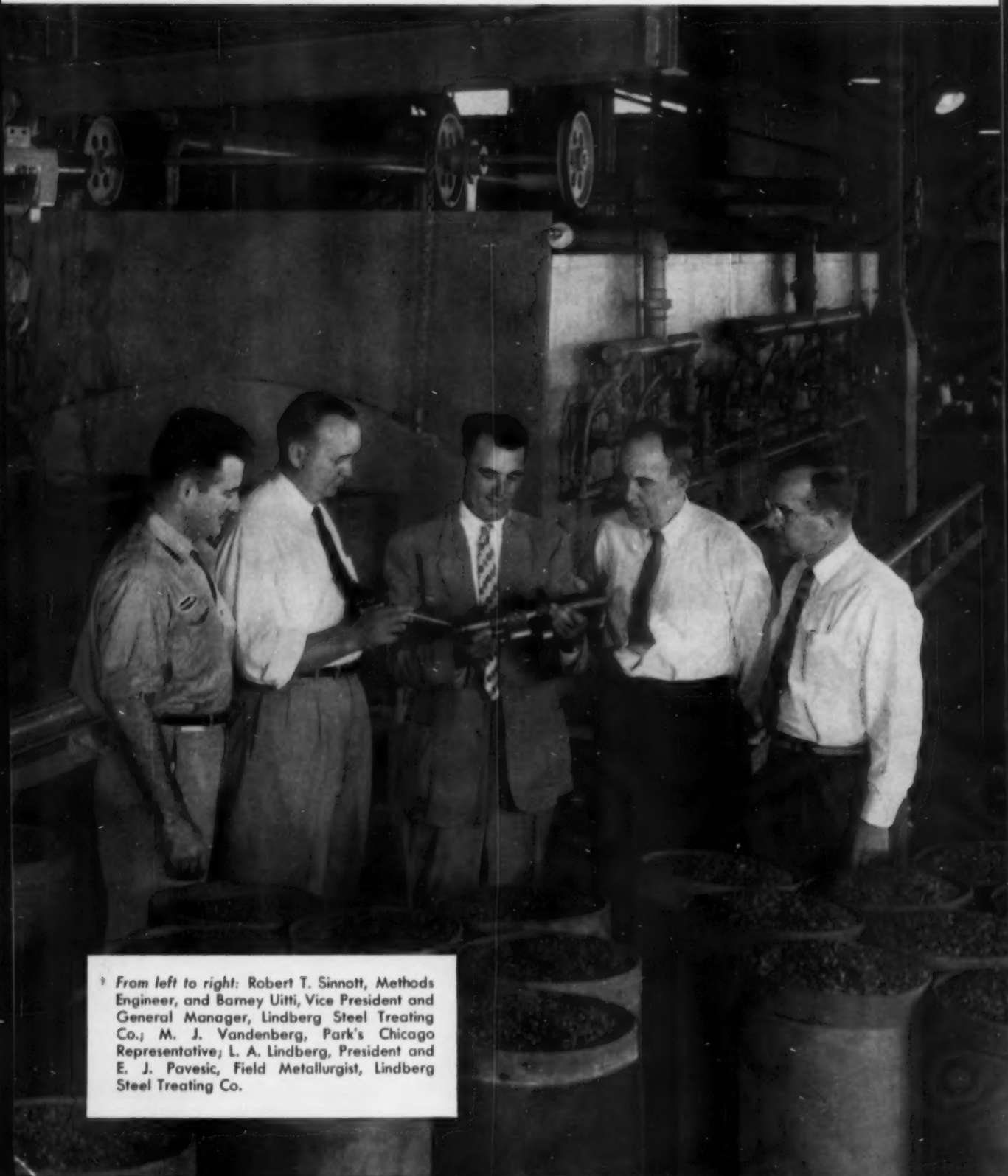
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Gulf Sales Engineer T. F. Irving checks with Frank Buettner, heat treating foreman, on the results of hardness obtained in heat treating bolts at Lamson and Sessions' plant in Cleveland, Ohio.



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Machining time, such as planing, rough cutting, milling, hand benching and burring are appreciably reduced on Finkl SMQ Die Blocks. Thorough field testing shows that the Special Machining characteristic of SMQ saves shop time and gets the die into production sooner.

There is a Finkl steel available for any forging need. All are quality controlled through each step from our own melt shop to final inspection.

When you next consider die blocks, your local Finkl representative will gladly help you plan for "impressions that last."

**DIE BLOCKS  
HOT WORK  
STEELS  
FORGINGS  
ELECTRIC  
FURNACE  
STEELS**

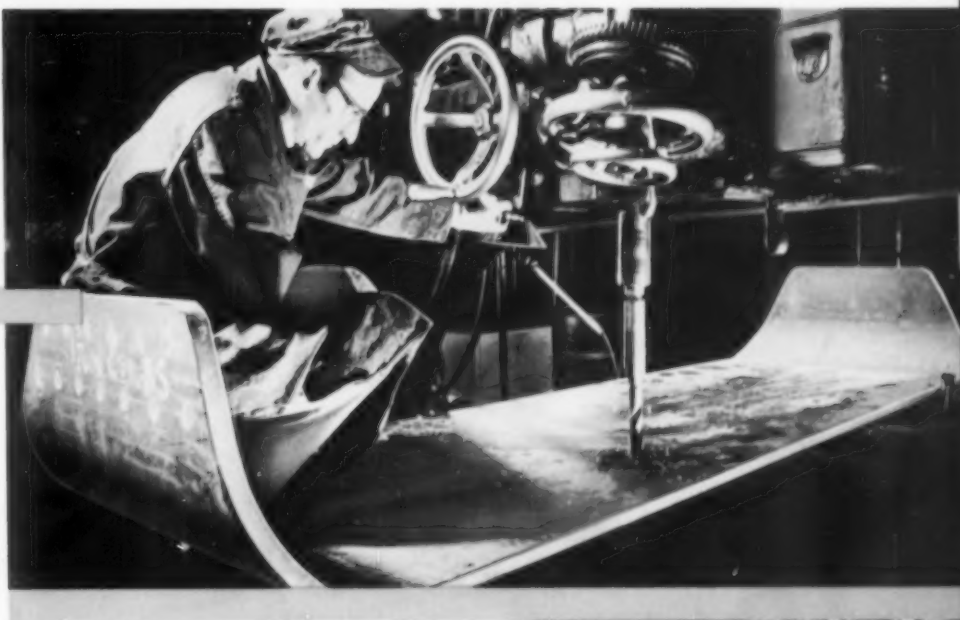
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# HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...

## ... Lops Off 1,047 Lbs.

Trays for ore clean-up buckets need tremendous resistance to impact, abuse, and abrasion. Blaw-Knox Company, Pittsburgh, Pa., found that they weigh half a ton less, and cost less to fabricate when made from USS "T-1" Steel plate instead of heavy steel castings.



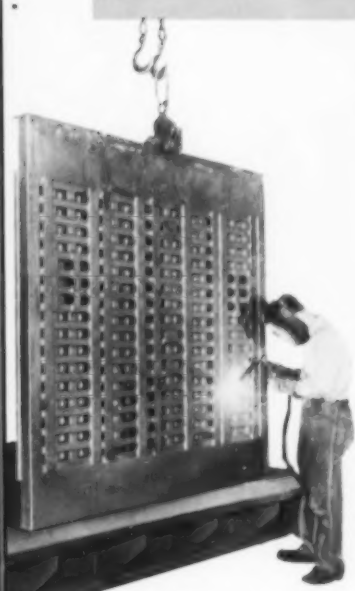
## Three Ways Better...

International Nickel Company of Canada expects USS "T-1" Steel to increase the service life, to reduce the maintenance, and lower the long-term cost of ore cars like this one; because "T-1" Steel has far greater strength, toughness, and resistance to abrasion than steel used previously. The car builder, Canadian Car and Foundry Co., Ltd., has had no difficulty fabricating this very strong alloy steel.



## ... 534 Easier Welds

This printing press bedplate manufactured by Graver Tank & Manufacturing Co., Inc., must be welded in 534 places. High alloy steel with the needed strength was very difficult to weld. But USS "T-1" Steel is easy to weld... and has the needed strength to keep these bedplates, used on high-speed printing presses, as lightweight as possible.



## HOW USS "T-1" STEEL CAN HELP YOU

The great strength and toughness of USS "T-1" Steel (90,000 psi, minimum yield strength) helps you to increase the capacity and durability of power-shovel buckets and storage tanks without increasing weight.

Its excellent weldability enables you to fabricate large equipment out in the field without heat treatment. It thus reduces fabricating and shipping costs and speeds up construction.

Its unusual toughness at sub-zero

temperatures improves service life of equipment that must take impact, abrasion, and abuse in all weather.

USS "T-1" Steel also gives you good creep-rupture strength to 900°F. It often can be substituted for more expensive steels that are more difficult to fabricate. There is a place for "T-1" Steel somewhere in your designs. Write, wire, or phone for complete information. United States Steel, Room 5320, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.

UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS **"T-1"** CONSTRUCTIONAL ALLOY STEEL

See The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.



UNITED STATES STEEL



Roll is shown at Homestead Forgings Division of United States Steel being bored, prior to heat treatment and reaming. Machine is 48" center drive, double end boring lathe.

Glass melting tank is at left. Forged Stainless rolls squeeze the viscous glass between them before it enters annealing lehr. ▼



# rolls glass at 2000°F with Stainless Steel rolls

In a sizzling race to keep up with the demand for flat glass, Pittsburgh Plate Glass Company is rapidly building new factories and increasing the output of old ones. But you cannot increase the output of an existing factory unless you can somehow get more glass from the melting tanks.

Since plate glass must pass between a pair of rolls as it emerges from the tank, the rolls must turn faster when production is increased. If they turn faster, it is more difficult to dissipate the heat from the molten glass. The answer is better rolls. And when you're thinking in terms of better rolls for hot work, stainless steel forgings are the answer.

Pittsburgh Plate has found that USS Quality Forging rolls have suitable physical properties and microstructure that are so necessary for this job. They are made from Type 410 Stainless Steel, and are remarkably resistant to surface cracking and checking. The rolls are water cooled internally, and there is naturally a steep temperature gradient from O.D. to I.D. The forged rolls resist pitting and oxidation. They retain their dimensions during the 24-hour-a-day glassmaking process.

Pittsburgh Plate has had one set of these rolls in continuous service for two years, and they have already produced millions of square feet of glass. Similar rolls will also be installed in their revolutionary new Cumberland, Md. plant.

Write today for our free booklet that describes USS Quality Forgings. Address inquiries or requests for the booklet to United States Steel, Room 2801, 525 William Penn Place, Pittsburgh 30, Pa.

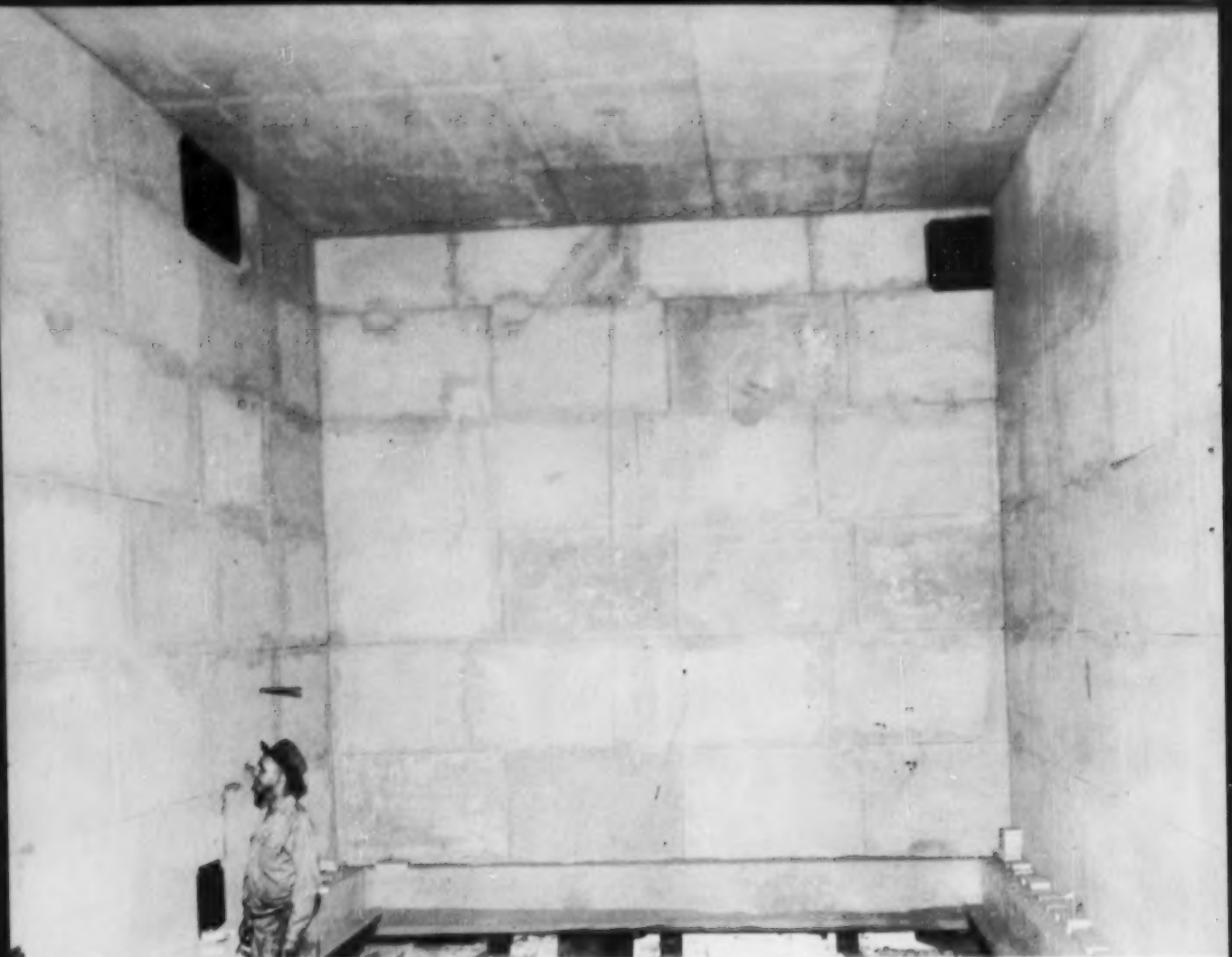
## USS QUALITY FORGINGS



*heavy machinery parts—carbon, alloy, stainless  
forged steel rolls and back-up roll sleeves  
electrical and water wheel shafts  
specialty forgings of all types*

**UNITED STATES STEEL**





• Made entirely of pre-cast refractory concrete blocks, this furnace is giving dependable performance at Goslin-Birmingham Mfg. Co., Birmingham, Alabama.

## Pre-cast blocks of Lumnite\*-made concrete give excellent service in big furnaces



• Lumnite can take it. These big castings ride on car top made with Lumnite refractory concrete.

"This furnace was built for stress-relieving gray iron castings, and steel weldments. We encountered no difficulty in casting or erecting pre-cast blocks, of which entire furnace was constructed. It has operated with minimum trouble and is very satisfactory," reports Mr. A. W. Varnon, Plant Superintendent of Goslin-Birmingham Mfg. Co.

Furnace linings made with pre-cast refractory concrete blocks, or cast monolithically, can save time and money in your plant, too. Construction is fast and easy, with Lumnite calcium-aluminate cement, or Lumnite-base castables. Just pour refractory concrete

in simple wooden forms. Lumnite reaches service strength within 24 hours.

Keep a supply of Lumnite cement or Lumnite-base castables on hand for other time- and labor-saving uses around your plant. You can make refractory concrete *designed for your specific job* by just adding water to a factory-prepared castable mix. Castables are made and distributed by leading manufacturers of refractories.

### UNIVERSAL ATLAS CEMENT COMPANY

UNITED STATES STEEL  CORPORATION SUBSIDIARY  
100 PARK AVENUE, NEW YORK 17, N. Y.

\*LUMNITE® is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company L-130

# Atlas® Lumnite Cement

FOR INDUSTRIAL CONCRETES  
REFRACTORY • INSULATING • OVERNIGHT • CORROSION-RESISTANT

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United States Steel Hour—Televised on alternate Wednesdays—See your local newspaper for time and station.



# Tool Steel Topics



On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor:  
Bethlehem Steel Export Corporation



## Bearcat Puts the Eye in Eye Bolt ... And Does It Economically

Putting the eye in an eye bolt is one thing, but doing it quickly, accurately and economically on thousands of pieces is something else again. J. H. Williams & Co., Buffalo, who make wrenches, tools and drop-forgings, changed to Beareat for the punching operation shown here. They found that because of Beareat's fine wear-resistance and shock-resistance, the punch provided a service life about

50 per cent longer than the one previously used.

The Beareat punch, hardened to Rockwell C 56-58, works on steel stock  $\frac{1}{8}$  in. and  $\frac{5}{16}$  in. thick, and knocks out discs approximately  $\frac{3}{4}$  in. in diameter. About 0.020 in. to 0.040 in. is removed in occasional redressing.

Beareat is our super-tough, air-hardening, general-purpose grade of tool steel. It is perhaps best known for its exceptional resistance to shock and wear. Besides, its air-hardening characteristic minimizes quenching hazards, and also provides excellent resistance to distortion in heat-treatment.

Beareat has a wide range of tough applications, too. In addition to its use in punches, it's a natural for rivet sets, chisels, gripper dies and hot-headers. It is also ideal for master hobs, and for dies used in blanking, bending, and cold-forming.

Your local tool steel distributor has a stock of Beareat, and chances are good that he can furnish exactly what you need. Call him now, while you have it in mind.



## BETHLEHEM TOOL STEEL ENGINEER SAYS:



*Choosing the Grade  
Means More  
Than Naming the Tool*

Let's say you have a general tool-and-die application, for which you are to select the proper grade of tool steel. How do you go about it? Obviously, it is not enough to know that the customer wants high hardness and good wear-resistance, for these properties are always required, in some degree. What you need are the answers to the following questions:

1. How is the tool to be made?
2. How is it to be used? Blanking? Forming? Cutting?
3. How is the steel to be heat-treated?
4. Are machinability and wear-resistance important?
5. How close must size be held after heat-treatment?
6. What is the previous experience with this job? Which steels were used and what results were obtained?

Selecting tool steel grades, even when you want perfection of operation, isn't too hard when sufficient data is available. But without adequate information, you may find your selection is disappointing.



## TOOL STEEL MOVIE WINS ANOTHER AWARD

Bethlehem's tool steel color movie, "Teamwork," an award winner at film festivals at Columbus and Chicago, recently won a Certificate of Merit at the Cleveland Film Festival.

The 16-mm, 30-minute picture explains the quality control and heat-treatment of Bethlehem tool steel, and shows typical applications of the carbon, oil- and air-hardening, shock-resisting, hot-work, and high-speed grades.

It's excellent for showing to heat-treaters, die-makers, machinists and machine-tool manufacturers, as well as to technical societies and engineering students. If you would like to schedule a showing of "Teamwork," send your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

# Get one or all OF THESE 12 FREE CATALOGS TO COMPLETE YOUR TESTING MACHINE REFERENCE FILE



This set of Riehle catalogs covers the complete line of Riehle Testing Machines that will solve your materials testing problems. Check coupon for the catalogs you want and we'll send them promptly, without obligation.

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*One test is worth a thousand expert opinions*

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Send me catalogs on these Riehle machines:

- ☐ **UNIVERSAL HYDRAULIC TESTING MACHINES AND ACCESSORIES** — In 3 models, with capacities to 400,000 pounds. With 5-scale range Pendomatic Indicating Unit or 2-scale range Bourdon tube indicating unit.
- ☐ **UNIVERSAL SCREW POWER TESTING MACHINES AND ACCESSORIES** — With 5-scale range Pendomatic Indicating Unit. Capacities up through 400,000 pounds.
- ☐ **CONSTRUCTION MATERIALS TESTING MACHINES AND ACCESSORIES** — For testing cement and concrete cylinders, masonry units, soil specimens, brick, tile and other construction materials. Built in 6 models with capacities from 60,000 lbs. through 400,000 lbs.
- ☐ **TORSION TESTING MACHINES** — For testing axles, crankshafts, airplane control rods and similar specimens. Built in 4 models with capacities ranging from 4,000 through 300,000 inch-pounds.
- ☐ **HORIZONTAL TENSILE TESTING MACHINES** — For stressing rope, cable and chain. Capacities to 500,000 lbs. with 5-scale ranges. Accommodate any specimen length required.

- ☐ **CREEP TESTING MACHINES** — Can be furnished as a complete "package." Capacities 12,000 and 20,000 pounds.
- ☐ **BRINELL HARDNESS TESTERS** — Fully hydraulic operation. For standardized loads of 500, 1500, and 3000 kg. meeting revised ASTM standards with loading accuracy of 1%.
- ☐ **VICKERS HARDNESS TESTERS** — Most versatile hardness tester known. Loads can be varied from 1 to 120 kgs. and readings are in one continuous scale from the softest to the hardest of metals.
- ☐ **PORTABLE HARDNESS TESTERS** — In 2 models, the smaller handles specimens of 5 inches diameter, and the larger, 12 inches. The larger tester weighs only 11 lbs. Readings in Rockwell scales A, B, C, D, F and G.
- ☐ **CABLE AND WIRE TESTERS** — For multiple proof-testing of cable with fittings. Capacities: up to 6500 lbs. Has 5 loading units, each with individual automatic timer and control.
- ☐ **IMPACT TESTING MACHINES** — A combination machine for making Izod, Charpy or tension tests. Can also be furnished as a single purpose machine. Capacities up to 220 foot-pounds.
- ☐ **TESTING MACHINES GUIDE** — An 8-page Bulletin covering the line of Riehle Testing Machines and Instruments.

# APPLICATION and EQUIPMENT

## new products

### Vacuum Heat Treating Furnace

A new facility for vacuum or controlled atmosphere heat treating has been announced by NRC Equipment Corp. The furnace has a resistance heated uniform hot zone 36 in. in diameter by 36 in. high. The maximum working temperature is 2000° F. and minimum pressure 0.5 microns. The vacuum furnace makes possible



bright surfaces, assures reproducible results, prevents adverse changes in the surface chemistry and removes surface contaminants. It can be employed to restore the ductility of hydrogen-embrittled titanium and zirconium. The unit may also be used for sintering, brazing, hardening and degassing. The vertical arrangement of heating element and vacuum bell makes it suited for mechanized production operations.

For further information circle No. 959 on literature request card, p. 48-B.

### Tool Steel

The Timken Roller Bearing Co. has announced a new low-temperature air-hardening tool steel which hardens from 1450 to 1525° F. Due to the low hardening temperatures, Graph-Air is less susceptible to decarburization and distortion in heat treatment. It has excellent machining qualities,

high resistance to wear and good anti-frictional properties. It will be available in the full size range of solid and hollow bars.

For further information circle No. 960 on literature request card, p. 48-B.

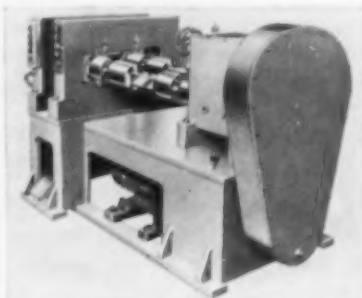
### Silver Alloy

A new oxidation-hardenable high-silver alloy, offering a combination of good electrical and mechanical properties, has been announced by Handy & Harman. The alloy is a silver-magnesium-nickel composition, normally consisting of about 99.53% Ag, 0.27% Mg and 0.20% Ni. It is easily worked while soft and then irreversibly hardened by heating in air. Once hardened, the alloy is highly resistant to softening, has a low creep rate, and for all practical purposes does not anneal at elevated temperature. In the as-received (annealed) condition, silver-magnesium-nickel alloy is soft like fine silver or copper, and finished parts can be formed by stamping, drawing, bending, spinning, usually without anneals. If annealing is necessary, it can be done in 15 to 30 min. in air at 700° F. or in nonoxidizing atmosphere above 700° F. Permanent oxidation hardening is produced at 1200 to 1475° F., the time and temperature cycle dependent on the thickness of the piece.

For further information circle No. 961 on literature request card, p. 48-B.

### Compacting Metal Powders

A new vertical rolling mill for progressive compacting of metal powders has been announced by the Fenn Mfg. Co. The vertical mill fea-



tures the work rolls in a horizontal plane. Metal powder is fed vertically into the rolls from a hopper located above the roll housings, and a chute arrangement beneath the rolls provides for delivery of the compacted strip for sintering. The mill is work-roll driven by a heavy-duty universal drive built to transmit heavy torque loads to the precision-ground 6 by 8 in. rolls. Maximum separating force is 150,000 lb. and a 15 hp. four-speed drive permits rolling speeds from 5 to 30 f.p.m.

For further information circle No. 962 on literature request card, p. 48-B.

### Die Casting Machine

American Die Casting Machinery Co. has announced a new high speed die casting machine that will handle shot capacities up to 2½ lb. Other outstanding features include: all-steel welded construction, 80-ton locking pressure, automatic electric cycling

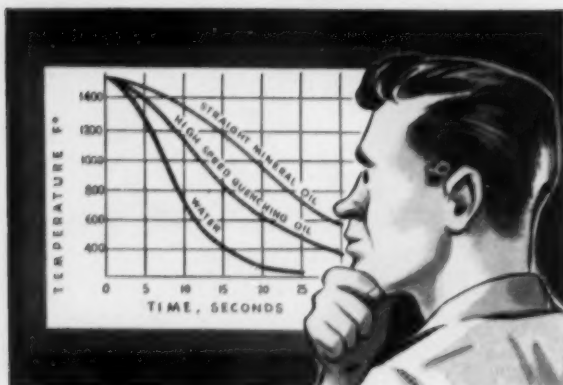


at high speed (up to 700 shots per hour), 17½ by 17½ in. die platens and 6½ in. die stroke. The machine is available as air or hydraulic operated plunger gooseneck-type for zinc, tin and lead, or cold chamber type for aluminum, brass and magnesium.

For further information circle No. 963 on literature request card, p. 48-B.

### Radiography

An isotope radiography machine for portable field work has been announced by the Budd Co. The Multi-tron, which was built for the Newport News Shipbuilding and Drydock Co., employs the radiation from 50 curie cobalt-60 source and may be used to detect possible defects in atomic reactor shielding. It is capable of pene-



**1. Quenching Speed.** There are two basic types of quenching oils...straight mineral oils and compounded high-speed oils. If you can get the microstructure and hardness you need and have no distortion problems with a straight mineral oil, then it's the type to use. If you're not getting the results you want, increased agitation may help. If increased agitation doesn't help, or isn't practical, you should use a high-speed oil.



**2. Naphthenic vs. Paraffinic.** Both types of oil are used for quenching. Both have their own inherent advantages. Naphthenic oils keep oil coolers cleaner when the temperature of the oil doesn't exceed 150 F. A fully dewaxed paraffinic oil gives the most satisfactory results at temperatures over 150 F. As a rule, when all other operating factors are equal, the temperature of your oil bath tells you which type of oil to use.

## What's the difference in quenching oils?



**3. Thermal Stability.** This is the biggest single factor influencing the useful life of a quenching oil. The higher the temperature of the oil bath, the shorter the life of any given oil. As mentioned before, at temperatures over 150 F it takes a stable, fully dewaxed paraffinic oil to give the most satisfactory results. For maximum useful life at temperatures over 200 F you will probably need a specially inhibited quenching oil.



**4. Other Considerations.** When quenching from a salt pot, use a straight mineral oil. Don't use an oil containing lard oil or other vegetable or animal fats. The salt carried into the oil on the parts will cause these fats to saponify and form oil-thickening grease. For bright quenching, experience shows that a straight mineral oil will give the best over-all results. For the most part, a straight oil will give cleaner parts longer.

These facts are nothing more than a guide to help you select the quenching oil best suited to your particular needs. To arrive at the final answer, there's no substitute for experience. Sun's representatives, backed up by Sun's metallurgical staff, have that experience. And, they're backed up by a *complete* line of quenching oils, paraffinic or naphthenic, regular or high-speed, straight or inhibited. Sun makes them all. For more information, see your Sun representative or write SUN OIL COMPANY, Philadelphia 3, Pa., Dpt. MP-10.

INDUSTRIAL PRODUCTS DEPARTMENT  
**SUN OIL COMPANY**  
 PHILADELPHIA 3, PA. ©SUN OIL CO.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO and MONTREAL



trating very heavy sections of steel, lead and other materials and can accomplish the same job as a 2,000,000 volt X-ray machine. Remote control operation allows the source to be ex-



posed at distances up to 50 ft. from the operator with complete safety. Internal and panoramic exposures may be made with the Multitron. It is used to detect flaws in castings, welded joints, pressure vessels and pipe lines. For further information circle No. 964 on literature request card, p. 48-B.

### High-Vacuum Still

A new high-vacuum brush-type still with high fractionating power has been announced by the Rochester Div. of Consolidated Electrodynamics Corp. This batch-type unit separates heat-sensitive materials with molecular weights up to 900 at pressures as low as 1 micron Hg. It has a distillant capacity of 100 to 1500 cc., with a distillation rate from a few drops to 100 cc. per minute. Exact regulation of the distillant boiler up to 300° C. is provided by variable transformers. A vacuum gage indicates pressure between 1 and 1000 microns Hg.

For further information circle No. 965 on literature request card, p. 48-B.



### Ductility Testing

Testing the ductility of copper, brass, aluminum, tinplate, stainless steel and carbon steel 0.003 to 0.062 in. thick is the function of the new cup tester announced by Steel City Testing Machines, Inc. The cup tester

cleaned and back at work  
in 5 minutes

*Waukee*

**FLO-METER**



The Waukee FLO-METER can be cleaned and back in operation in five minutes or less! Saves time and money.

Inherent accuracy of the FLO-METER is protected by Waukee's design for fast, easy cleaning. No tools are needed. Production interruption at a minimum.

The Waukee FLO-METER also features: built-in Control Valves, panel mounting, simple piping, large 6" and 9" scales for ease of reading. Capacities 3 CFH to 10,000 CFH.

Complete information in Bulletin 203. Write for it. Waukee Engineering Company, 5140 North 35th Street, Milwaukee 9, Wisconsin.

For measuring: air — ammonia — dissociated ammonia — argon — butane — city gas — endothermic cracked — exothermic cracked — forming gas — helium — hydrogen — natural gas — nitrogen — oxygen — propane.

*Waukee*

**FLO-METERS • AIR-GAS MIXERS  
INDUSTRIAL WASHING MACHINES**

Now You Can Test

**CRATEX**  
RUBBERIZED ABRASIVES

*"cushioned action performance"*

**In Your Own Plant On  
BURRING, SMOOTHING  
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To meet the demand for "A Testing Kit" we have just developed the

**CRATEX POLISHING KIT**

Containing a comprehensive assortment of 24 of the most popular CRATEX Polishing Wheels, Cones, Blocks and 1/4" Shank Mandrels—in a variety of "grit textures"—especially engineered for plant craftsmen—including complete Instruction Bulletin—for either manual or machine applications.

For cleaning and polishing molds, dies & castings; removing film, coatings & enamel; blending in and polishing welded seams after rough grinding; polishing bearing surfaces and raceways; removing rust, heat-marks, tarnish, excess solder, fatigue lines, scratches, corrosion and other unacceptable surface defects.



**24 Items** Complete Kit **\$12.50**

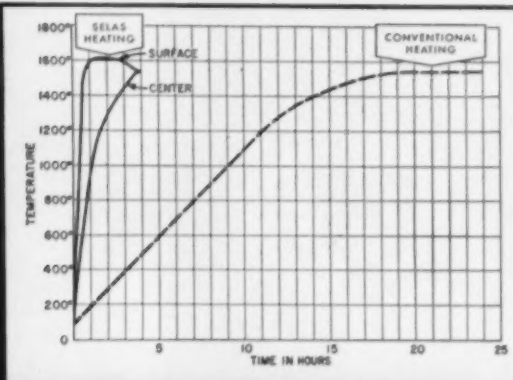
Investigate and test CRATEX Rubberized Abrasives—"the world's finest for industrial use"—unduplicated for lowering "unit costs." The "cushioned action performance" gives unparalleled results on production and assembly lines; in tool and machine shops. Send for Illustrated Catalog showing wide range of sizes, application details and prices.

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Order the CRATEX POLISHING KIT on your regular Purchase Order—send to us and we'll send the "KIT" through our Industrial Distributor in your area.

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81 Natoma St., San Francisco 5, Calif.

# FAST HEATING of LARGE STEEL SECTIONS is practical and safe with Selas Gradiation®



**FAST** heating is playing an increasingly important part in helping modern industry keep pace with today's high production requirements and exacting demands. In addition to the obvious increases in output, **FAST** heating opens the way to automatic, continuous processing of large steel sections.



**FAST:** At the Heppenstall Company, Pittsburgh, for example, alloy steel die blocks, 8" to 24" thick, are heated to 1550°F, for hardening, *five times faster* by Selas Gradiation than by conventional methods.

**SAFE:** Sonic testing of every Selas **FAST**-heated die block proves its flawless quality, reproducible uniformity.

**PRACTICAL:** The completely automatic program control heating accomplished in the Selas gas-fired furnace proves **FAST** heating is a practical tool for modern steelmakers.

Consider these additional Selas advantages: Precision timing of the heating cycle permits close scheduling of other facilities and manpower. Less labor and lower labor skills are required. Fuel savings of 20%. Quick, economical start-up.

The above furnace was prefabricated by Selas and installed intact in the Heppenstall plant with little or no production interference.

In another installation, Selas Gradiation **FAST** Heating handles steel sections up to 10' x 24' x 3.3' . . . weighing 192 tons . . . *five times faster* than by usual practices.

Write Dept. 610 for descriptive data and more information about Selas Gradiation **FAST** Heating

**SELAS**  
CORPORATION OF AMERICA  
DRESHER, PENNSYLVANIA

*Heat and Fluid Processing Engineers*  
DEVELOPMENT • DESIGN • CONSTRUCTION





is a bench-mounted hydraulically operated unit. The ball penetrator is a standard  $\frac{3}{8}$  in. diameter and the die supplied with the machine is a standard 1 in. diameter. Overall size of the new tester is 11½ by 21 by 25 in. high. Net weight is less than 200 lb.

For further information circle No. 966 on literature request card, p. 48-B.

### Heating Control

A safety shutoff and alarm for automatically controlled processes which require no sensing elements or electronic circuitry has been announced by Damol Corp. The present models are designed for heat treating furnaces but the principle of the impulse monitor can be applied to any process involving heat, pressure or flow where the control system uses an on-off, two position or pulsing type of control mode and where the input is of reasonably uniform duration. The operation of the impulse monitor is a direct function of the signal from the automatic controller. It continually monitors the input of the controlled process and acts when an abnormal condition arises. It can be wired to operate an external alarm circuit or to signal failure over telephone lines or protective agency equipment.

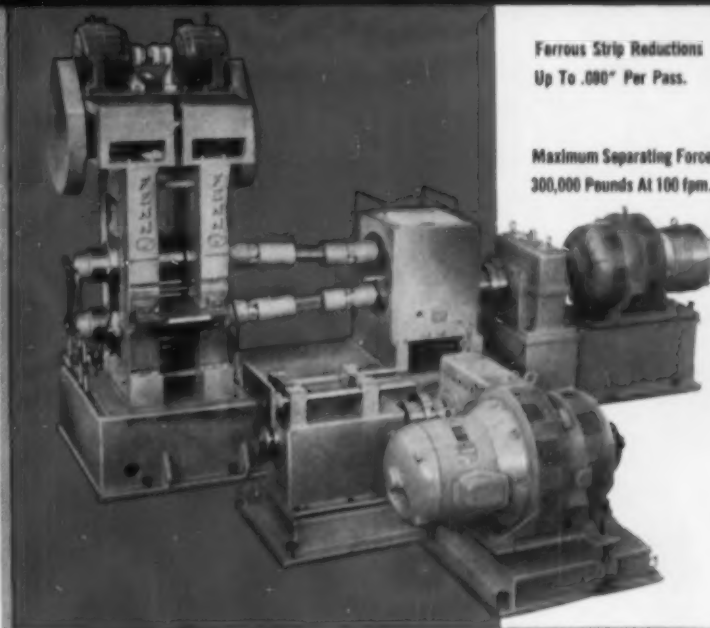
For further information circle No. 967 on literature request card, p. 48-B.

### Spot Welding Head

A new portable hand-held spot welding head for production line welding of small parts and assemblies has been announced by the Equipment Marketing Dept. of Raytheon Mfg. Co. Weldpliers weigh only 2½ lb. and are designed with a convenient and comfortable hand grip. Light finger pressure applies a constant welding force, adjustable from



## FENN INTRODUCES A NEW LARGE LABORATORY ROLLING MILL



Ferrous Strip Reductions  
Up To .080" Per Pass.

Maximum Separating Force  
300,000 Pounds At 100 fpm.

### PERMITS HEAVY REDUCTIONS IN THE LABORATORY ON FERROUS STRIP

Fenn's new Model 4-083 Combination Type Laboratory Rolling Mill, a companion to the popular smaller Fenn Mill, is capable of taking heavy reductions on ferrous strip at all speeds between 100 fpm and 500 fpm. The mill (2½" x 8¾" x 8") can be used as a two-high mill, or as a four-high mill featuring driven back-up rolls or work rolls, and many drive combinations are possible to meet customer specifications. Important features of the new mill include a dual motor power screw-down unit, force feed lubrication system, and auxiliary operator control stations.



### COMPLETE MILL SPECIFICATIONS

sent upon request.

Fenn engineering service is available to help you solve your rolling problems.



Precision  
Rolling Mills



Turbs Heads



Wire Shaping  
Mills



Swaging Machines



Wire and Tube  
Drawing Machines

Fenn Manufacturing Co., 506 Fenn Road, Newington, Connecticut

# HIDDEN flaws in your products need detecting?

Every day brings new inspection problems to Picker for possible solution. More often than not, radiography (or fluoroscopy) can help. Here's a typical week's score . . .

PROBLEM	SOLVED
glass splinters in some candy bars	✓
solder invasion of a precision resistor	✗
bubbles in glass containers	✓
poor bond in ceramic insulators	✓
failures in adhesives	✓
knives in crude rubber "biscuits"	✓
stringers in a highly-stressed lock nut	✓
clearances in a miniaturized amplifier	✓
solder tinning on a thin connecting lug	no ✗
porosities in a new type of false tooth	✓
welds in bandsaw blades	✓

Makes no difference what you make or buy or sell . . .

if it needs "seeing into" for quality control, radiography (gamma or x-ray) can probably profit you.

Talk it over with your local Picker representative \* or write us outlining your problem and, if possible, sending typical samples.

We'll make tests and tell you frankly whether radiography holds any promise for you. Costs you nothing to find out . . . maybe it's costing you a great deal right now NOT TO.

\* There's probably a Picker district office near you (see local 'phone book).



PICKER X-RAY CORPORATION  
25 South Broadway, White Plains, N. Y.

*Picker... your one Source for Everything in Radiography and Fluoroscopy*

1 to 25 lb., to the work pieces. Fast electrode follow-up during the weld is provided by a slight flexing of the cantilever-type electrode horns under welding pressure which tends to pull the electrodes together as the



weld becomes plastic. Water-cooled electrode holders permit high speed welding at powers up to 5 k.v.a. with a.c. power supplies and 600 watt-seconds with d.c. stored energy. For further information circle No. 968 on literature request card, p. 48-B.

### Cleaning Compound

Apothecaries Hall Co. has announced a new metal cleaning compound for descaling or derusting steel and iron parts. The new cleaner may be used for treating small parts in tumbling barrels.

For further information circle No. 969 on literature request card, p. 48-B.

### Powdered Metal Test Dies

Haller, Inc., has announced self-contained powdered metal test dies for briquetting test bearings. Core rods are secured to the die structure without increasing overall length and pins with hardened chromium steel



round dies are made to Metal Powder Assoc. standards for wall thickness. Lower member of the unit contains spring retainers and the guide pin base for a floating action which produces the effect of top and bottom

# Waltz gives you a complete heat-treating department



in a single unit

Waltz CH gas fired heat-treating unit gives you all the advantages of a full scale heat-treating department. Designed for heat-treating all types of oil or water hardening steel . . . for heating, quenching and drawing . . . for stress relieving, normalizing and annealing, with controlled atmospheres.

#### Features include:

1. Heating Furnace with range of 1000° to 2400° F. automatically controlled (12" wide x 10" high x 18" deep).
2. Tempering or Drawing Oven is recirculating type. Work is constantly bathed with evenly distributed high velocity and held to constant temperature by automatic control. Alloy steel lined with perforated shell, has range of 250° to 1100° F. (21" wide x 10" high x 18" deep).
3. Furnace and Oven doors equipped with foot treadles.
4. Two Quench Tanks for oil and water. By means of double wall construction, oil tank is entirely surrounded by water for cooling oil, thus producing more uniform quenching.
5. Automatic electronic type controls.
6. Shipped ready to install by simply connecting gas and electric power line.

A complete line of WALTZ standard or special heat-treating furnaces, using all types of fuels are built to suit your requirements. Write for comprehensive illustrated bulletins.

**Waltz furnace company**  
**SYMME STREET**  
**CINCINNATI, OHIO**

CHOICE  
 DISTRIBUTOR  
 TERRITORIES  
 NOW OPEN—  
 WRITE TODAY

Waltz Furnace Co.,  
 Symmes Street, Cincinnati, Ohio  
 Dept. W

Please send without obligation  
 engineering bulletins—Waltz Heat-  
 treating Furnaces.

NAME \_\_\_\_\_

COMPANY \_\_\_\_\_

ADDRESS \_\_\_\_\_

CITY \_\_\_\_\_

STATE \_\_\_\_\_

# Ferrocolumbium



## a new source

The use of Columbium is now free of any restrictions and may be again employed as a valuable alloying material, recognized for improving high temperature properties and increasing corrosion resistance.

In announcing the addition of this product to its line of metallurgical alloying elements, the same reliable MCA technology is offered that has distinguished MCA molybdenum, tungsten, boron and rare earths . . . faithful uniformity in fulfilling specifications . . . deliveries to accurately anticipate customer's requirements.

Further, the sources of supply for the raw material are plentiful, and will continue to increase.

MCA Ferrocolumbium is available in a variety of screen sizes to meet manufacturing requirements. It will pay you to investigate this new supply source, today.

## MOLYBDENUM

Grant Building

CORPORATION OF AMERICA

Pittsburgh 19, Pa.

Offices: Pittsburgh, Chicago, Los Angeles, New York, San Francisco  
Sales Representatives: Brunley-Donaldson Co., Los Angeles, San Francisco  
Subsidiary: Cleveland Tungsten, Inc., Cleveland  
Plants: Washington, Pa., York, Pa.



pressure in briquetting. As a result of this action, bearings are produced with uniform density.

For further information circle No. 970 on literature request card, p. 48-B.

### Metalworking Press

E. W. Bliss Co. has announced a line of single action eccentric geared two point presses based on a unitized principle of press construction. The principle involves a quill-mounted fly-wheel and overhung clutch built into a unitized gear case on which the main motor drive is mounted. Except for the main gears, nothing is built into the crown. As a result, the entire



drive can be removed from the press as a unit. All presses in the line are available as a basic press. Standard features of the basic unit include: all welded construction, with a four-piece frame and tie rods drilled for electrical shrinking; recirculating oil system; bronze liners on the slideways running against cast iron gibs.

For further information circle No. 971 on literature request card, p. 48-B.

### Seam Welder

A new vacuum dry-box unit which automatically welds parallel seams in thin gage reactive metals has been announced by Vacuum Specialties Co. It can be evacuated to less than 0.1 micron before back-filling with protective atmosphere. Longitudinal seams up to 5 ft. long and cross seams up to 10 in. are made with a deviation of less than  $\pm 0.0005$  in. in either the horizontal or vertical plane. The work is set up on a carriage which runs into



## Get UNIFORM QUENCH RESULTS with engineered agitation

If you're considering *violent turbulence* for your quenching operations, we'd like to drop this reminder:

Most of the people who use violent agitation in the quench bath do it with LIGHTNIN Mixers.

And without exception, these men report good heat treating results. Greater uniformity of hardness, all over the part and from one part to the next. Greater depth of hardness, resulting in higher over-all tensile strength and toughness. No re-treats and rejects due to soft spots. No warpage or cracking. For some steels, better machinability.

You can get LIGHTNIN Mixers for any type of immersion quenching, martempering, austempering; for use with any quenchant; any size, shape, and quantity of pieces, in new or existing tanks.

For information on the number, size, type, and cost of LIGHTNINS you will need to get the results you want, just call your nearest LIGHTNIN representative (listed in Thomas' Register) or write us today.

**"Lightnin"  
Mixers**

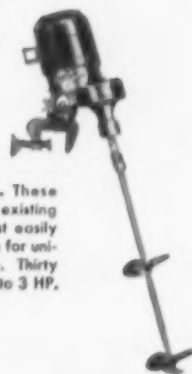
**MIXING EQUIPMENT Co., Inc.**

171-k Mt. Read Blvd., Rochester 11, N. Y.

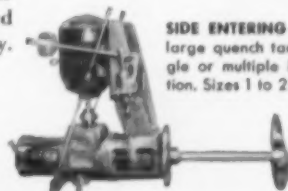
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 10, Ont.



**PERMANENT . . .** Often used as a component of new quench tanks and heat treating furnaces. Sizes  $\frac{1}{4}$  to 3 HP.

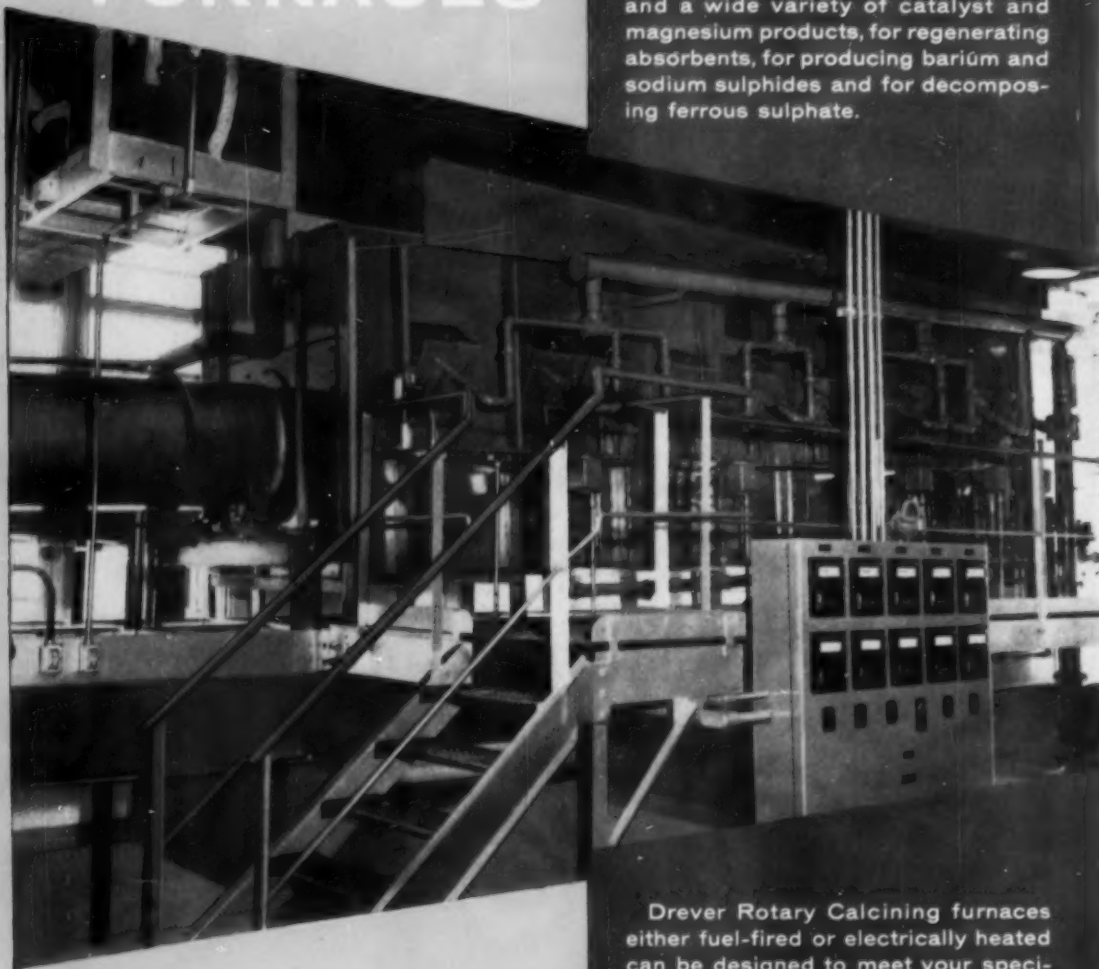


**PORTABLE . . .** These LIGHTNINS fit existing tanks, and adjust easily to the best angle for uniform turbulence. Thirty models; sizes  $\frac{1}{4}$  to 3 HP.



**SIDE ENTERING . . .** For large quench tanks; single or multiple installation. Sizes 1 to 25 HP.

# DREVER Rotary CALCINING FURNACES



Here illustrated is one of a group of four gas-fired calcining furnaces which is used to dry special catalytic material after pelletizing.

Furnaces of this type find wide application in such operations as calcining lithopone and titanium pigments and a wide variety of catalyst and magnesium products, for regenerating absorbents, for producing barium and sodium sulphides and for decomposing ferrous sulphate.

Drever Rotary Calcining furnaces either fuel-fired or electrically heated can be designed to meet your specifications. We would welcome your inquiry involving specialized calcining and drying operations.

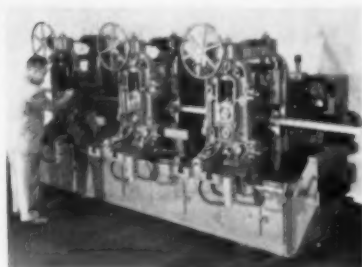


RED LION RD. and PHILMONT AVE. • BETHAYRES, PA.

the stainless steel tank on tracks. The carriage has provision for revolving the work by remote control and is moved back and forth along the axis of the tank by a variable speed rack and pinion drive with the motor, gear box and controls outside the chamber. The welding head is moved back and forth by a hydraulic cylinder and piston located outside the chamber. The thoriated tungsten electrode is manually raised and lowered from the operating position at the large sight port. **For further information circle No. 972 on literature request card, p. 48-B.**

### Straightening Machine

Sutton Engineering Co. has announced a new contour correcting and straightening machine developed to correct cross-sectional distortions of aluminum extrusions. Designed for change-over to different extruded shapes, the machine employs multiple



rolls of simple design, providing flexibility to correct cross-sectional distortions. The machine is furnished with one or more contour correcting stands, with provision for additional stands to be added.

**For further information circle No. 973 on literature request card, p. 48-B.**

### Water Conditioning Compound

Klem Chemicals, Inc., has announced a new noncaustic, nonoily, nonfoaming compound for conditioning the water, protecting equipment and reclaiming paint in all types of water-type spray booths. It forms a protective film around paint molecules, causing them to float rather than sink. The "captured" paint can be skimmed off and reclaimed.

**For further information circle No. 974 on literature request card, p. 48-B.**

### Machining Test Specimens

A new portable machine for the machining of tensile specimens from sheet and plate materials has been announced by Sieburg Industries, Inc. Ferrous and nonferrous specimens 0.0005 to 0.500 in. thick can be machined to ASTM specifications in less than 3 min. The new model with increased controlled power produces un-

## YOU'LL DO BETTER WITH UNITCASTINGS!

We make no *special* claims to produce miracles with cast steel. Like competitive foundries, problems are similar . . . equipment may differ slightly . . . it's the *end performance* of the casting that counts!

A little *extra* surveillance in process pays off quality-wise. Customers receive better, cleaner castings . . . meeting accepted specifications . . . and end up with a lower *finishing* cost. Less scrap . . . less re-work . . . and less lost production time amounts to more than incidentals!

Standard carbon and low alloy steel castings, up to 150,000 psi tensile . . . whatever your requirements, specify Unitcastings!

UNITCAST CORPORATION • Toledo 9, Ohio

In Canada: CANADIAN-UNITCAST STEEL, LTD., Sherbrooke, Quebec

# Unitcast



**QUALITY  
STEEL  
CASTINGS**

another revolutionary development by La Salle

# THE **NEW** *fatigue-proof* STEEL BAR

## *gives* **HIGH STRENGTH... WITHOUT HEAT TREATING**

"FATIGUE-PROOF" steel bars offer high strength in-the-bar . . . *without the expense and trouble of heat treating.* Tensile strength is in the 140,000 to 150,000 p.s.i. range . . . hardness, which is related to this strength level, is approximately 30 Rockwell "C."

"FATIGUE-PROOF" has uniform

strength across the bar . . . and this uniformity is maintained from bar to bar . . . lot to lot. This remarkable uniformity of strength makes "FATIGUE-PROOF" ideal for applications in the 140,000 to 150,000 p.s.i. range that formerly required heat treated carbon and alloy steels, either hot rolled or cold drawn.

## *yet it's* **EASY TO MACHINE**

"FATIGUE-PROOF" machines at least 25% faster than annealed alloys . . . 50% to 100% faster than heat treated alloys.

"FATIGUE-PROOF's" excellent machinability permits faster speeds, heavier feeds, better tool life . . . your production rates will increase.

Distortion from machining is held to a minimum . . . surface finish is greatly improved.

Our Sales Engineers will be happy to show you how you can cut costs and eliminate problems and provide samples for test purposes.

**JUST PUBLISHED!** Ask for your copy of this new 20-page booklet which gives additional information on the remarkable new "FATIGUE-PROOF."



**La Salle STEEL CO.**

1424 150th STREET • HAMMOND, INDIANA

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars

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Please send me your "FATIGUE-PROOF" Bulletin.

Name

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Company

Address

City  Zone  State

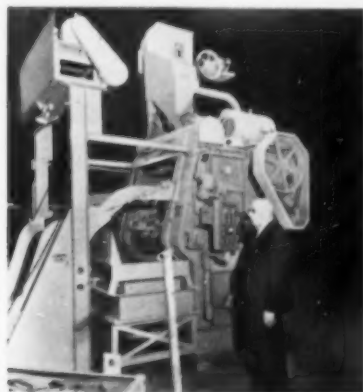


distorted edges with no measurable amount of cold working and with no evolution of heat. A master template controls the specimen tolerances to an accuracy of  $\pm 0.0005$  in.

For further information circle No. 975 on literature request card, p. 48-B.

### Blast Cleaning

A fully-automatic Blastmaster barrel, in which all operations including material handling, weighing, starting and stopping the rotation of the barrel are automatic, has been announced by the Pangborn Corp. A 12 cu. ft.

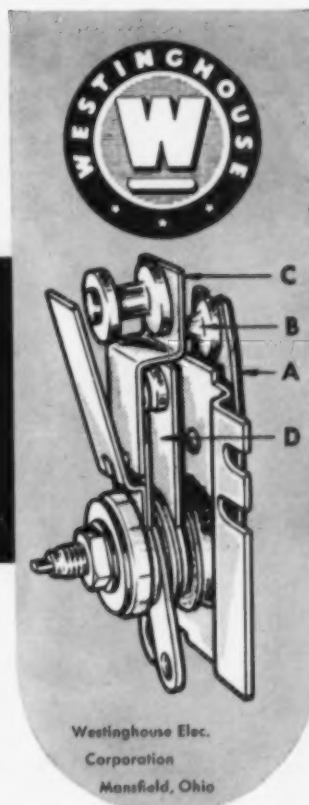


Blastmaster barrel with a Rotoblast wheel  $19\frac{1}{2}$  in. diameter with 3 in. throwing vanes is shown in the illustration. A 15 hp. motor drives the wheel which can throw 24,000 lb. of shot per hr. The new automatic blast cleaning barrel can be furnished in 6, 12, 18 and 27-cu.ft. sizes.

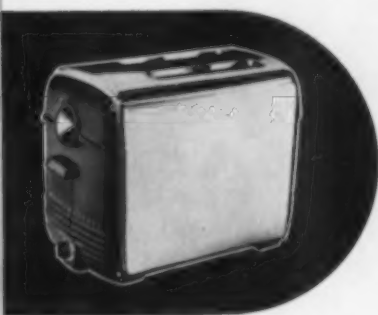
For further information circle No. 976 on literature request card, p. 48-B.

### High Temperature Electric Furnace

The L & L Mfg. Co. has announced a new series of electrical heated furnaces with ranges to 2500 and 2750° F. Special silicon-carbide heating elements are used. Construction is of heavy sheet steel. All units are of floor-type construction and transformers, controllers and temperature controls are installed in the base of the



HOW CHACE  
THERMOSTATIC  
BIMETAL ACTUATES THE  
**WESTINGHOUSE**



*Pop-Up  
Toaster*

Uniform toasting in just 90 seconds is featured by this new Westinghouse pop-up toaster. A new type of heating element is combined with a reflector on each side of the two slices. Its unique dual element thermostat compensates for variations due to voltage fluctuations and reduced browning of the second and third slices. The controlling elements are accurate, dependable Chace Thermostatic Bimetal, of course.

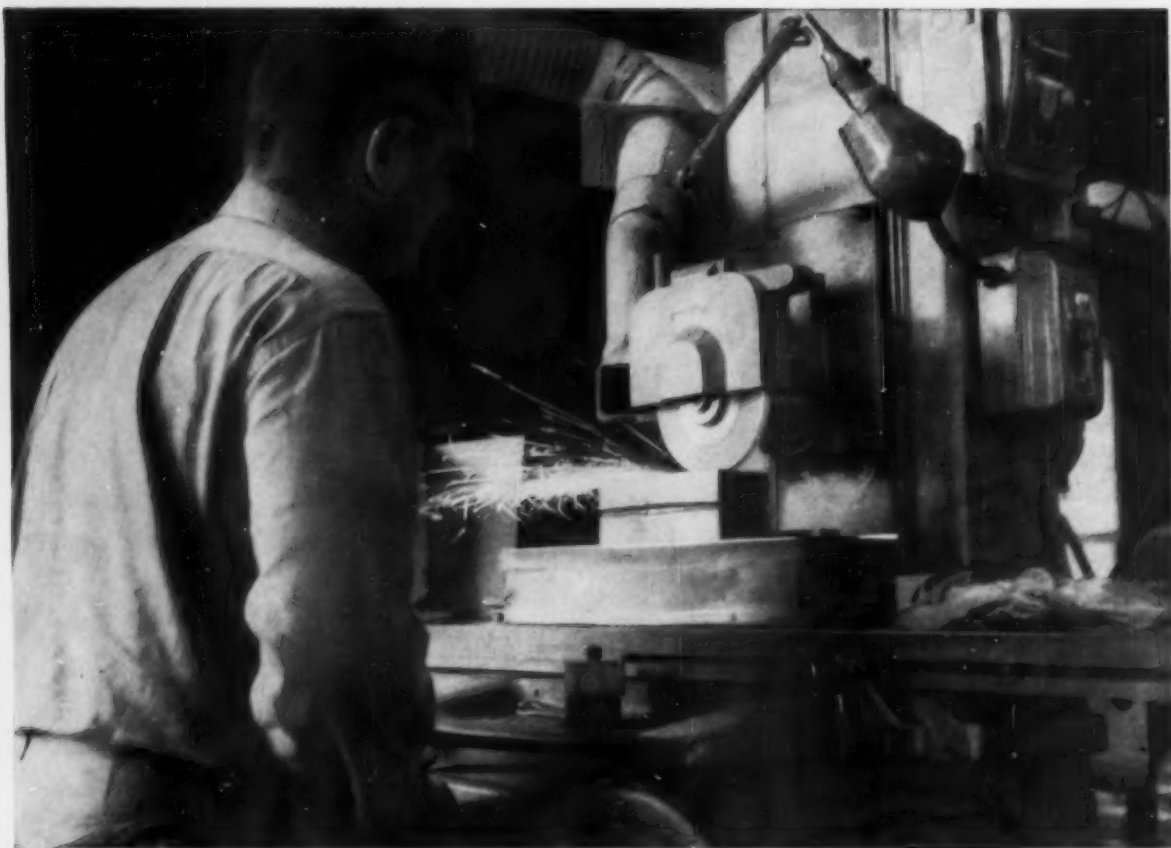
The operation of the thermostat is ingenious: the right hand bimetal element (A) controls the temperature of the air in the toasting chambers, hence the degree of browning. This highly responsive bimetal is positioned so it is exposed to the radiation from the heating element. High voltage (more heat) makes the element deflect to the left and the ceramic point (B) moves the upper spring-mounted contact arm at (C), opening the circuit, thus preventing over-browning. When voltage drops, the effect is opposite.

The left hand bimetal element (D) controls browning of second and third slices. Being of a much less responsive type, it is gradually deflected to the left by the ambient temperature in the toaster, moving the contact arm (C) and prolonging the period of the circuit.

Chace Thermostatic Bimetal is available in 28 types, in strip, coil or completely fabricated and assembled elements made to your specification. Write for new 44-page booklet, "Successful Applications of Chace Thermostatic Bimetal," containing interesting uses of bimetal, formulas, calculations, etc.



**W. M. CHACE CO.**  
*Thermostatic Bimetal*  
1626 BEARD AVE., DETROIT 9, MICH.



## "5 years ago Cities Service solved all our lubrication problems and we've never had another!"

A report from Banner Spring & 4 Slide Co., Van Dyke, Michigan

**These Were The Problems 5 Years Ago:** Banner Spring & 4 Slide Company, maker of small parts for the automobile, electrical and refrigeration industries, was having trouble. Ways, bearings, and drive shafts on 4 Slide machines were getting insufficient film strength from lubricants and constantly burning out. Likewise, compressors were also running hot, and there was complete puzzlement over what type of lubricant to use for Banner's high-speed sewing machines.

Banner decided to call in a Cities Service Lubrication Engineer. A thorough survey followed, with the man from Cities Service carefully examining each machine and its particular operating conditions.

This completed, he made his recommendations — Trojan H-2 Multi Purpose Grease for the 4 Slide machines, Pacemaker No. 1 Oil for the compressors, and Pacemaker 00 Oil for the high-speed sewing machines.

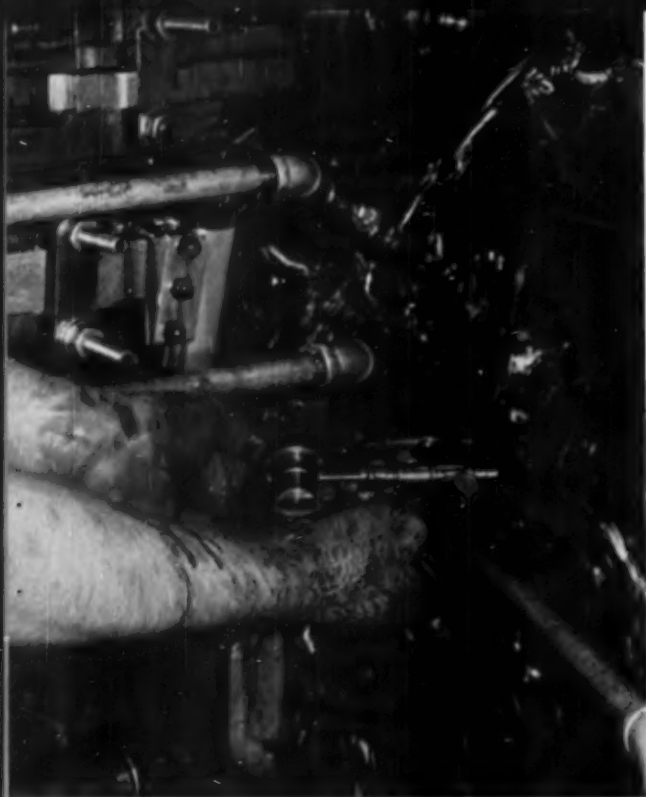
Banner followed these recommendations to the letter. Result: Not one lubrication problem in the past five years — despite the fact that machinery runs 24 hours a day!

If you're faced with a lubrication problem — or if you're just not sure if your present lubricant is best for the job — talk with the man from Cities Service. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.



**SOME BANNER PRODUCTS:** The firm makes all kinds of round wire forms, wire springs, metal clips and flat springs. Use for such products ranges from auto fender support rods to "burlap listings"—the wire frames sewn into burlap which back up automobile upholstery.

**CITIES SERVICE**  
QUALITY PETROLEUM PRODUCTS



**Black cutting oil** (left) makes close control difficult. Operators dislike dirty operating conditions it creates. Close control is easier and workers are happier with transparent Sunicut cutting oil (right).

## WHY USE A BLACK CUTTING OIL WHEN YOU DON'T NEED IT?

**Sunicut oils give you better visibility without sacrificing machining efficiency.**

When trying to maintain close control over machines producing precision parts, operators can be handicapped by "black-oil blindness". It is hard to see the tools, the workpiece, and the finishes. Checking close tolerances is difficult when the graduations on micrometers and gauges are obscured.

Worse still, as the operator sees it, are the dirty working conditions caused by dark oils. His clothes get saturated with hard-to-remove stains, and his hands are black from one end of the shift to the other.

Transparent Sunicut oils help keep your operators happy and will make close control easier ...and transparent Sunicut oils will do the job with no sacrifice in machining speed or finishes.

To get the full story on Sunicut oils, see your local Sun representative, or write **SUN OIL COMPANY**, Philadelphia 3, Pa., Dept. I-41.



**INDUSTRIAL PRODUCTS DEPARTMENT**  
**SUN OIL COMPANY** PHILADELPHIA 3, PA.  
© SUN OIL CO.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL



*For any machining or grinding operation...*

## **THERE'S A SUN OIL THAT'LL GIVE YOU HIGH EFFICIENCY AND LOW OVER-ALL COST**

No two machine shops have exactly the same problems when it comes to selecting cutting oils...even when they're running the same job. And, until somebody comes up with the truly universal cutting oil, you can't afford to disregard the importance of oil selection. Here's how Sun can help you.

First, Sun makes a complete line of emulsifying and straight cutting and grinding oils. Second, your Sun representative, backed up by field engineers, has the necessary practical experience to recommend

the oil that will give you both high machining efficiency and low over-all costs.

For the full story about Sun's cutting oils, see your Sun representative...or write **SUN OIL COMPANY, Philadelphia 3, Pa., Dept. I-42.**



**INDUSTRIAL PRODUCTS DEPARTMENT**

**SUN OIL COMPANY** PHILADELPHIA 3, PA.  
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unit except special controls which require a special instrument panel. Insulation is of multi-layered type.

For further information circle No. 977 on literature request card, p. 48-B.

### Drop Forging

A new piston-lift gravity drop forging hammer has been announced by Erie Foundry Co. The all-steel air operated hammer gives its operator

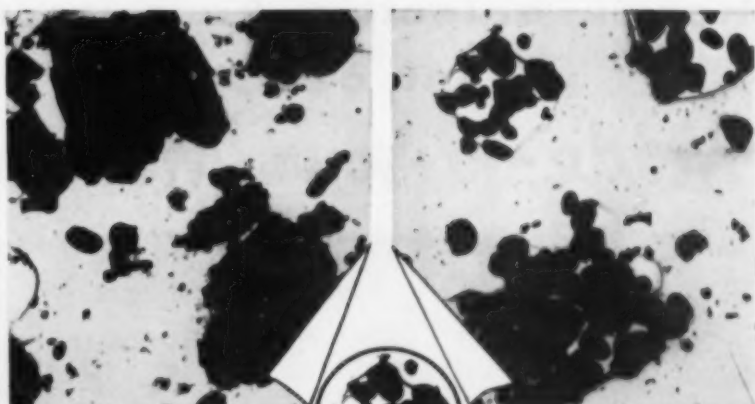
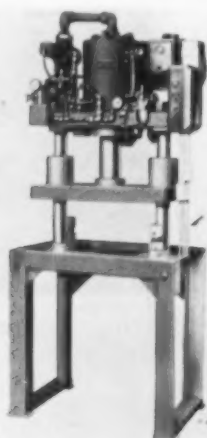


complete control of stroke variation, allowing him to select from the full range of strokes between the conventional short and long, by varying pressure on the hammer's treadle. It is available in sizes from 1500 through 5000 lb.

For further information circle No. 978 on literature request card, p. 48-B.

### Trimming Press

A new high speed 20-ton hydraulic trim press designed for the die casting industry has been announced by Mohler Engineering Co. The press is operated by a 3 hp. motor. The ram travels at high speed in both directions. The press is engineered around the parallel strain rod, guided platen principle. Typical operations of this



"TITANOX" — RCHT, nitrocellulose substrate, a titanium calcium pigment consisting of 30 parts titanium dioxide and 70 parts calcium sulfate (X19,000).

The same after the nitrocellulose pigmented film has been specially treated to dissolve the calcium sulfate, revealing the real structure of the titanium calcium pigment (X19,000).

## They Saw the Real Structure of Titanium Calcium Pigment for First Time!

### RCA Electron Microscope at National Lead Company Reveals Make-up of this Useful Material

Development of the Electron Microscope over the years to the present high level of efficiency has permitted extended exploration in the field of pigment technology. According to W. R. Lasko of the Research Laboratory of National Lead Company, Titanium Division, South Amboy, N. J., "The RCA Electron Microscope has revealed for the first time the real structure of titanium calcium pigment. We found that the particles of titanium dioxide in this widely useful pigment are coalesced around the surface of the calcium sulfate. Thus, identification of the individual components is possible. Size and shape of the calcium sulfate as well as of the titanium dioxide can readily be observed. The titanium dioxide industry has been immeasurably aided by the electron microscope."



### RCA RADIO CORPORATION of AMERICA

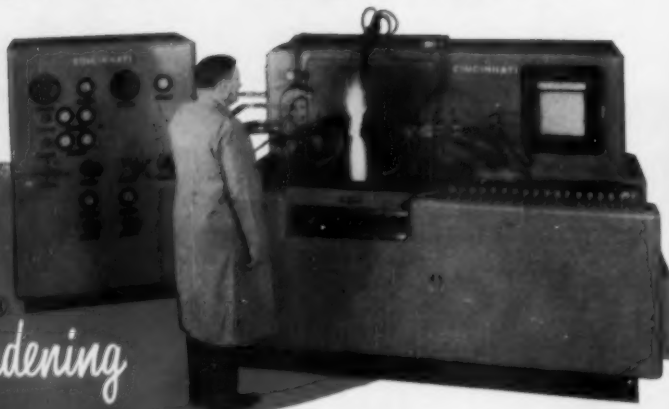
Whether your field of micrographic interest lies in metals and pigments, or in products of any one of the dozen or more industries now using the RCA Electron Microscope, your studies, too, can no doubt be immeasurably aided by this magnificent new research tool. For further information, write to Dept. K-72, Building 15-1, Radio Corporation of America, Camden, N. J. In Canada: RCA VICTOR Company Limited, Montreal.

Installation Supervision is supplied, and contract service by RCA Service Company is available with the Electron Microscope, if desired.

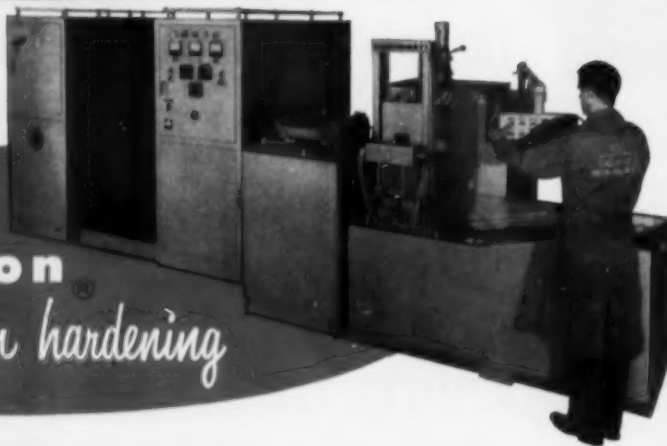
Here's selective heat treating  
that can be  
**Made-To-Your-Measure!**



**flamatic**  
*flame hardening*



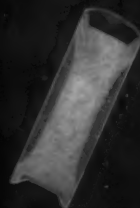
**inductron**  
*induction hardening*



Cincinnati does both—selective flame or induction hardening—and the parts shown at right are typical of those that can be hardened by either method. If that's your situation, then talk to Cincinnati . . . headquarters for equipment that gives you the hardness wanted, where it's wanted, using the heat source most economical for you. Use electric power—or acetylene, propane, natural or manufactured gas—whichever is readily available to you or provides lowest cost.

Whether flame or induction, you can be assured of heat-treating machinery that will deliver the hardness you specify, and meet your cost-per-piece requirements, on high production quantities or varied, small-lot runs. It will be excellently engineered, equipped with the finest of components, thoroughly safeguarded, easily maintained.

Call in a Process Machinery Division field engineer. He is ideally equipped to evaluate your needs and give you unbiased recommendations as to the most economical equipment for your selective surface hardening work.



Transmission pinion pin



Locking pin



Bevel gear



Steering arm ball stud



Locking pawl



**flamatic and inductron**  
*hardening machines*

THE PROCESS MACHINERY DIVISION  
**THE CINCINNATI MILLING MACHINE CO.**  
CINCINNATI 9, OHIO, U. S. A.

press include broaching, staking, swaging, stamping, shearing, blanking and forming.

For further information circle No. 979 on literature request card, p. 48-B.

### Electroplating

A new plating bath level control which is impervious to plating acid deterioration has been introduced by Elkhart Controls Co. This unit maintains a constant level with no danger of mechanical or electrical failure. It has a 36-in. fill tube which adds water as needed at the bottom of the tank, maintaining the solution within a tolerance of  $\pm \frac{1}{8}$  in. Tanks must be at least 3 ft. deep for proper operation.

For further information circle No. 980 on literature request card, p. 48-B.

### Abrasion Tester

The resistance to surface abrasion of materials under cold, wet and dry conditions can be evaluated by the use of the new automatic model of abrasion tester, announced by Taber



Instrument. Evaluating the resistance of surfaces to rubbing abrasion is accomplished by means of the dual abrading wheels which traverse a complete circle on the surface tested.

For further information circle No. 981 on literature request card, p. 48-B.

### Lubricant Testing

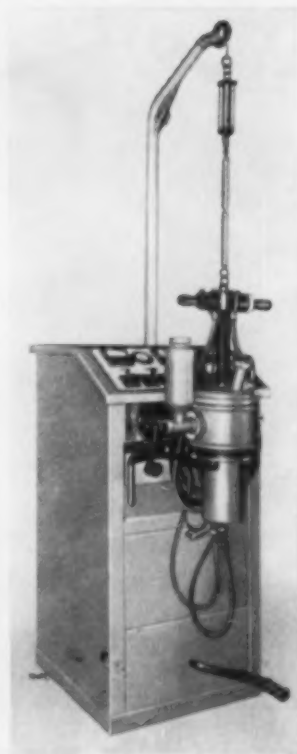
A new lubricant-friction wear testing machine has been announced by the Alpha Molykote Co. The new machine has been developed for testing bonded coatings. It can also be used for testing liquid lubricants. The machine is a relatively small table model which indicates friction forces throughout the test. A pre-setting device automatically shuts off the machine after it reaches a predetermined coefficient of friction.

For further information circle No. 982 on literature request card, p. 48-B.

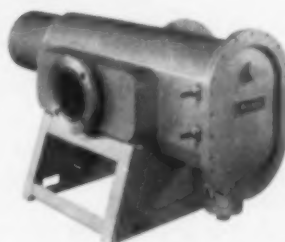
OCTOBER 1956

## Cr, Hf, Ir, Mo, Nb, Os, Pd, Pt, Re, Ta, Ti, V, W, Zr

### Get pure vacuum melts of these metals in minutes!



The Heraeus Vacuum Arc Melting Furnace Model VA-L200B, smallest of a line of Heraeus Furnaces sold by CEC.



This Roots pump maintains low, vapor-free pressures. A motor operating within the vacuum drives its rotary frictionless pistons.

With this new Heraeus Arc Melting Vacuum Furnace, the VA-L200B, you can get vacuum melts in "buttons" or ingots.

You can get them of Titanium, Zirconium, Tungsten, and other metals or alloys with high melting temperatures. You can get them fast and pure.

**Super-fast mechanical pump**—A Roots mechanical vacuum pump pulls pressures in the furnace down to  $5 \times 10^{-2}$  mm Hg—fast.

Its throughput of 10,400 micron CFM at 10 microns easily handles sudden gas bursts encountered with certain metals.

**No oil contamination**—The Roots pump's frictionless rotary pistons require no oil sealing. There can be no contamination from backstreaming vapors in the system.

**No crucible contamination**—The Heraeus furnace has a water-cooled, copper crucible which cannot contaminate the melt.

**Fixed or consumable electrodes**—You may use either fixed electrodes of tungsten or metallic carbides, or consumable electrodes of the metal you are melting.

This Heraeus furnace has many other features valuable in laboratory or small-scale production, including exceptional economy—operating either under vacuum or with an inert gas atmosphere.

Heraeus of Hanau, Germany, has licensed CEC as exclusive agent for Heraeus Arc Furnaces (and Roots Pumps) in this country. Complete details in our Bulletins P8-20 and P4-28.



**Consolidated ElectroDynamics**  
Rochester Division, Rochester 3, N. Y.

*formerly Consolidated Vacuum*

NATIONWIDE COMPANY-OWNED SALES AND SERVICE OFFICES



## A wink built for speed!

The speed of a wink varies, depending upon its purpose . . . and its target. The femme fatale's provocative wink from the dim recesses of a cocktail lounge may pack the wallop of a Sabre-Jet, yet its speed is a languorous one-tenth of a second. Imagine a wink five hundred times as fast! Fairchild Camera and Instrument Corp. has produced a camera that does just that. Its shutter speed is 1/5000th of a second . . . a speed made possible only by using Titanium shutter leaves. Such shutter speeds are essential in guided missile research and the development of supersonic devices.

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# APPLICATION and EQUIPMENT

## new literature

### 984. Abrasion Tester

Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Tabor Instrument*

### 985. Abrasives

Catalog on range of sizes, applications, prices of rubberized abrasives. *Crater Mfg.*

### 986. Allowable Stresses

Data Card 154 gives max. allowable stress values for 22 types of steel tubing. Formulas for calculation of max. working pressures. *Babcock & Wilcox*

### 987. Alloy Castings

Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

### 988. Alloy Castings

Data folders on two types of alloy steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

### 989. Alloy Castings

22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

### 990. Alloy Steel

Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

### 991. Alloy Steel

207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

### 992. Alloy Steel

32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

### 993. Alloy Steel

40-page book on applications of heat treated, special alloy steel. *Jones & Laughlin*

### 994. Aluminum Bronze

8-page booklet on study that led to development of one-piece, nickel-aluminum bronze ship propeller. *International Nickel*

### 995. Aluminum Cleaning

Folder on five aluminum cleaners and methods of cleaning aluminum for welding. *Northwest Chemical*

### 996. Aluminum Extrusions

Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

### 997. Analysis of Nickel Alloys

52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys". *International Nickel*

### 998. Atmosphere Furnace

Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

### 999. Atmosphere Furnace

Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

### 1000. Atmosphere Furnace

12-page bulletin 1054 on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

### 1001. Atmospheres

Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

### 1002. Automatic Control

40-page catalog No. 4A shows design and various models of contact metal relays. *Assembly Products*

### 1003. Batch-Type Furnaces

Bulletin SC-174 on furnaces in the operating range of 1400 to 1750° F. for various heat treating processes. Suction radiant tube fired units and mechanized systems. *Surface Combustion*

### 1004. Bearings

Chart on chemical, mechanical and work characteristics of sintered bronze or iron bearing materials. *Bound Brook Oil-Less Bearing*

### 1005. Bimetal Applications

New 44-page booklet, "Successful Applications of Thermostatic Bimetal", contains uses, formulas, calculations. *W. M. Chace*

### 1006. Black Oxide Coatings

8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

### 1007. Blast Cleaning

24-page catalog 1210 on equipment and accessories for blast cleaning and dust control. *Pangborn*

### 1008. Bolts

16-page booklet on high-strength bolting for structural joints includes ASTM specifications covering this bolting material. *Bethlehem Steel*

### 1009. Bonding Plastics

New literature on new method of bonding Teflon and Rulon by surface treatments. *Dixon Corp.*

### 1010. Boron Additive

6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

### 1011. Bronze

Folder gives tables of properties, uses, forms and other data on phosphor bronzes. *Chase Brass & Copper Co.*

### 1012. Brush Finishing

4-page bulletin on precision brush finishing of cylindrical parts with centerless grinders. *Osborn Mfg.*

### 1013. Burners

Bulletin 212 on dual-fuel burners for oil or gas. Combustion characteristics, burner operation, burner construction, piping. *North American Mfg.*

### 1014. Burners

8-page bulletin on ribbon gas burners for continuous heat processing. *Selas*

### 1015. Burnishing

Bulletin B-10 on new series of compounds aids in selection of proper compound. *Apothecaries Hall*

### 1016. Calibrating Machine

Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

### 1017. Carbon Control

12-page catalog TD4-620 (2) on Microcarb atmosphere control for carbon potential in Homocarb furnaces. *Leeds & Northrup*

### 1018. Carbon Determination

New catalog on carbon and sulphur determinators. *Harry W. Dietert Co.*

### 1019. Carbon Refractories

New catalog section on carbon products for cupola furnaces gives physical prop-

### 983. Vapor Degreasing

This 24-page booklet on vapor degreasing includes descriptions of straight vapor, vapor and liquid, conveyORIZED units and special systems which embody



vapor phases. Several pages are devoted to discussion of installation, operating techniques, accessory equipment, troubleshooting and solvent recovery. Cut-away diagrams explain basic degreaser design. *Circo Equipment*

erties of carbon refractories and describes applications. *National Carbon*

### 1020. Carburizing

16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

### 1021. Carburizing Salts

Folder on salts for liquid carburizing. *Swift Industrial Chemical*

### 1022. Casehardening

32-page booklet on casehardening of steel by nitriding. *Armour Ammonia Div.*

### 1023. Castings

New 16-page booklet, "Cast to Outlast Destructive Service", gives latest information and case histories on use of sand, centrifugal and precision investment castings. *International Nickel Co.*

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"Shirt-sleeve" service, on your job and in your plant, goes with every Houghton salt you buy. A team of specialists is added to your heat treating staff—men who are backed up by many years of experience and the most extensive research facilities in the business. It is their job to see that you get the heat treating results you want, no matter how difficult the assignment.

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### 1024. Centerless Grinding

28-page reprint gives advantages, applications and economics, fundamentals and methods, machines and attachments, wheels and wheel selection chart. *Key-stone Abrasive Wheel Co.*

### 1025. Chromate Finishing

File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

### 1026. Chromium Plating

4-page bulletin on new "crack-free" chromium plating process. *United Chromium*

### 1027. Chromium Plating

New folder gives advantages of new additive. Tables of compositions of plating solutions. Charts. *Diamond Alkali*

### 1028. Cleaning

28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

### 1029. Cleaning

Folder on di-phase cleaning gives equipment, construction features, spray and blow-off features, heating systems. *Solventol*

### 1030. Cleaning

Folder on steel shot for cleaning aluminum castings, gray iron castings, steel forgings and for shot peening. *Steel Shot Producers, Inc.*

### 1031. Coatings

Bulletin on coatings of tungsten carbide. Preparing parts for fusecoating. Allowances for distortion. *Fusion Metal Coating Co.*

### 1032. Cold Finished Bars

Engineering bulletin, "New Economies in the Use of Steel Bars". *LaSalle Steel*

### 1033. Cold Rolled Steels

32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

### 1034. Compressors

12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

### 1035. Continuous Mill Drives

10-page booklet describes new mill drive incorporating a differential gear with variable speed hydraulic unit for each stand with all stands driven by a common line shaft from the main motor. *Mannesmann-Meer Engineering*

### 1036. Conveyors

Bulletin on conveyor standardization describes prefabricated sections for making customized conveyors. *May-Fran Engineering*

### 1037. Copper Alloys

48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Reverse*

### 1038. Corrosion of Copper

28-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

### 1039. Corrosion Resistance

20-page booklet on nickel, chromium, molybdenum, iron alloy gives chemical composition, corrosion data, properties and welding characteristics. *Haynes Stellite*

### 1040. Cut-Off Wheels

Folder gives data, operating suggestions and grade recommendations of cut-off wheels. *Manhattan Rubber Div.*

### 1041. Cutting Oil

Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

### 1042. Cutting Tools

New 12-page catalog D-56 on aluminum oxide cutting metals, tool tips, throw-away inserts, cylinders and other machine turning and cutting tools. *Metal Carbides*

### 1043. Degreasing

New bulletin on OPNT vapor degreaser describes and diagrams its construction. *Circo Equipment*

### 1044. Demineralization

24-page article on demineralizing considers development, trends and applications of multi-bed and mixed-bed ion exchange. *Graver Water Conditioning*

### 1045. Electric Furnaces

Folder on electric furnaces with zone control, temperature indication, automatic control. *L & L Mfg. Co.*

### 1046. Electric Furnaces

Bulletin on electric heat treating furnaces gives summary of progress in furnace developments. *Holcroft*

### 1047. Electric Furnaces

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

### 1048. Electron Microscope

20-page brochure describes in detail ten case histories in which the electron microscope has been at work solving problems of development and control in industrial laboratories. *RCA*

### 1049. Electron Tubes

Folder on tubes for industry, research and other applications. Separate data sheets give description, operating conditions, constant current characteristics. *Machlett Laboratories*

### 1050. Electronic Micrometers

Bulletin 4003 on direct reading electronic micrometers describes and illustrates 4 models. *J. W. Dice Co.*

### 1051. Environmental Equipment

4-page folder on low, high-temperature and humidity testing. Applications, performance, construction and specifications. *Tenney Engineering*

### 1052. Extensometer

8-page bulletin on extensometers for sheet metal and wire, compressometers, defectometers and other accessories. *Baldwin-Lima-Hamilton*

### 1053. Fabrication

Booklet on welded steel heavy fabrication pictures and describes how various products are made. *R. C. Mahon*

### 1054. Flaw Detection

Illustrated bulletin on Spotcheck, new dye-penetrant method for locating surface defects. *Magnaflux*

### 1055. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. *Waukeg Eng'g*

### 1056. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

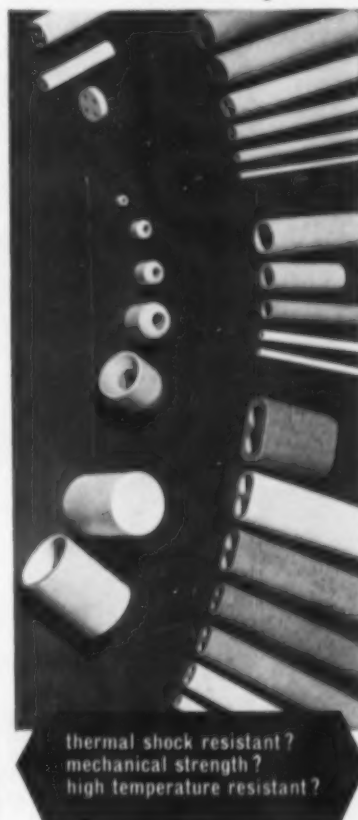
### 1057. Forgings

8-page booklet, "What Is a Forging?", on how forging idea originated and grew, how forgings are made and importance of forgings in modern products. *Drop Forging Assoc.*

### 1058. Forgings

Series of articles on modern forging methods. *Hill Acme*

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One or more of these SERV-RITE thermocouple insulators will take care of your needs. If not, there are many more in Gordon's large stock for quick delivery. If you need something entirely special, it can be made to suit your specific requirements.

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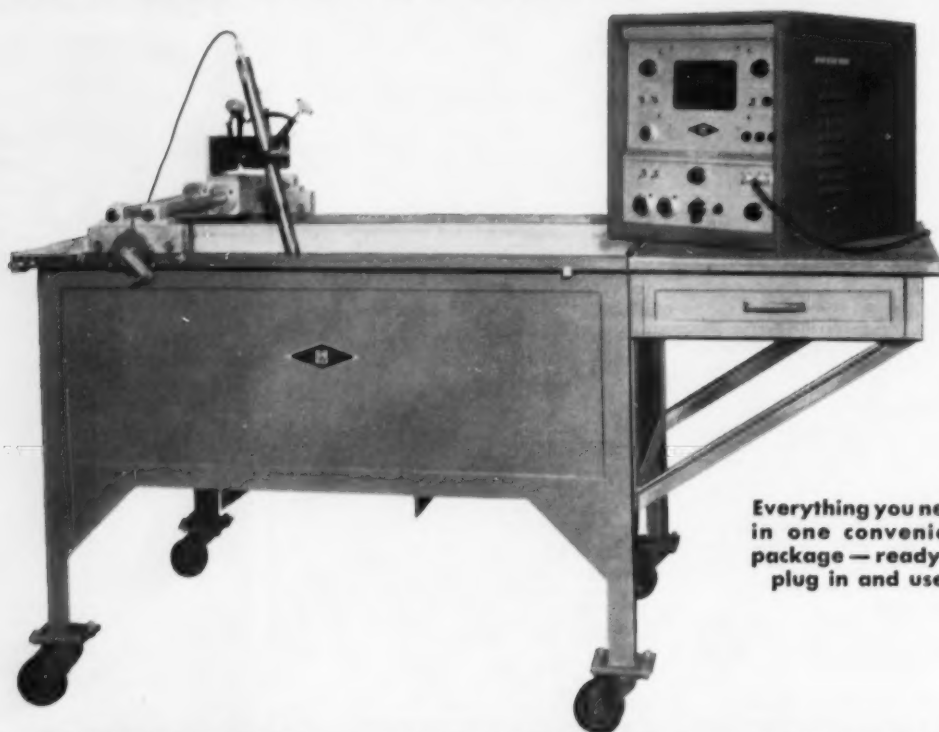
This new 4-page bulletin gives specifications and ordering data on all Gordon standard SERV-RITE thermocouple insulators grouped for easy selection.

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Everything you need  
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plug in and use.

## A COMPLETE, ECONOMICAL PACKAGE for immersed non-destructive testing

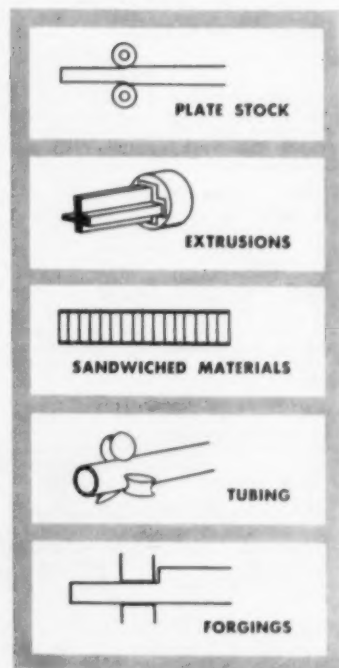
Now Curtiss-Wright offers all the benefits of immersion ultrasonic testing of metal without the expense of purchasing an assembly of several costly separate units. This new low cost "package" combines in a self-contained single unit the Immerscope — the heart of the system — a four-foot tank, search tube and rack, precision manual manipulator, longitudinal and transverse manual scanning mechanism and a complement of crystals. Here is a complete immersion testing, quality control installation ready to operate, whether in laboratory or light production — a system that can be readily expanded, with only minor investment, for more demanding production applications.

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### 1059. Forgings

Bulletin on forge steelmaking, open die forging, machining, heat treating and finishing. *National Forge*

### 1060. Forgings

Folder on large forgings of carbon and alloy steel. *Struthers Wells Corp., Titusville Forge Div.*

### 1061. Forming Stainless

24-page booklet describes processes applicable, contouring shaped sections, drawing, spinning, upsetting, hot forming and forming tubing. *Crucible Steel*

### 1062. Fuels

8-page booklet tells of the rapid growth and uses of liquefied petroleum gas. *Gulf*

### 1063. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

### 1064. Furnace Brazing

No. 2 of Cambridge Wire describes use of wire belts in furnace copper brazing. *Cambridge Wire Cloth*

### 1065. Furnace Controls

Condensed catalog on strip chart, circular chart, circular scale, Electronik controllers and other controllers, safety devices and valves. *Minneapolis-Honeywell*

### 1066. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

### 1067. Furnace Fixtures

Bulletin 111 on cast Ni-Cr fixtures for gas carburizing. *Fahrlooy*

### 1068. Furnaces

Complete information on custom built furnaces for all types of work. *Martin Mfg.*

### 1069. Furnaces

32-page catalog of industrial equipment includes furnaces and furnace accessories, special valves, mechanical equipment, materials handling equipment. *Salem-Bronits*

### 1070. Furnaces

Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

### 1071. Furnaces

Brochures on pot furnaces, nitriding, austempering, and martempering and salt baths. *A. F. Holden*

### 1072. Furnaces

16-page Bulletin 135 on industrial furnaces and atmosphere generators. Continuous systems. *Continental Industrial Engineers*

### 1073. Furnaces

6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

### 1074. Furnaces

Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

### 1075. Fused Silica

Folder on fused silica which is resistant to high temperatures, thermal shock, acids and has high electrical insulating value. *Amerail*

### 1076. Galvanometers

12-page bulletin 320 on galvanometers to meet varying conditions. *Rubicon Co.*

### 1077. Gas Analysis

Bulletin No. 306 on gas analysis kits for on-the-job determinations of carbon dioxide or oxygen in flue gases, furnace atmospheres and other gas mixtures. *Burrell*

### 1078. Gold Plating

Physical, thermal, chemical, electrical, diffusion and optical properties of electroplated gold. *Umes, Technic, Inc.*

### 1079. Gold Plating

Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

### 1080. Graphitic Tool Steel

48-page booklet on heat treating data, properties and 46 specific applications of graphitic tool steel. *Timken*

### 1081. Grinding Magnesium

Data on how to grind and polish magnesium alloys includes grinding wheel recommendations, procedures, dust collection and safety precautions. *Norton*

### 1082. Hardening Furnaces

Bulletin Sc-164 on hardening and drawing furnaces describes work handling mechanisms and heating methods. Chart of Rockwell hardness vs. drawing temperature for 40 steels. *Surface Combustion Corp.*

### 1083. Hardness Tester

Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

### 1084. Hardness Tester

Bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

### 1085. Hardness Tester

Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

### 1086. Hardness Testers

20-page book on hardness testing by Rockwell method. *Clark Instrument*

### 1087. Hardness Testers

Catalog of testers for normal hardness, superficial testing, accessory and special testers and micro and macro hardness testing. *Wilson Mechanical Instrument*

### 1088. Heat Exchanger

Bulletin 132 on sectional heat exchanger for use with quench bath, annealing furnace, wire drawing equipment and other industrial cooling functions. *Niagara Blower*

### 1089. Heat Treating

Folder illustrates various types of heat treating furnaces and auxiliary equipment. *Ferguson Equipment Corp.*

### 1090. Heat Treating

New edition of 73-page vest pocket data book on heat treating. Charts, tables, diagrams and factual data. *Sunbeam Corp.*

### 1091. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

### 1092. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

### 1093. Heat Treating Furnaces

32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

### 1094. Heat Treating Guide

Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

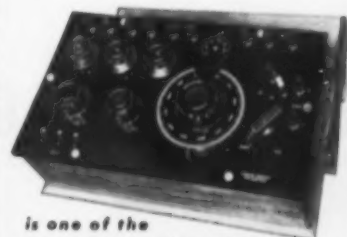
### 1095. Heating Elements

New brochure gives case histories of application of hot rod Crystolon heating elements. *Norton Co.*

### 1096. Heating Elements

24-page Bulletin H on electric heating elements. Includes extensive tabular data

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POTENTIOMETER

... a general purpose potentiometer with a number of notable refinements, suiting it particularly to thermocouple work. Distinctive features include:

- Three ranges—0 to 16 millivolts, 0 to 160 millivolts and 0 to 1.6 volts.
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- Special provisions to minimize parasitic thermal emf's—including automatic compensation of slidewire thermals and gold contacts in galvanometer key.
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Described in Bulletin 270



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FOR SHOP AND LABORATORY WORK

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- Multiple-reflection optical system
- 100-Millimeter scale
- For null or deflection measurements

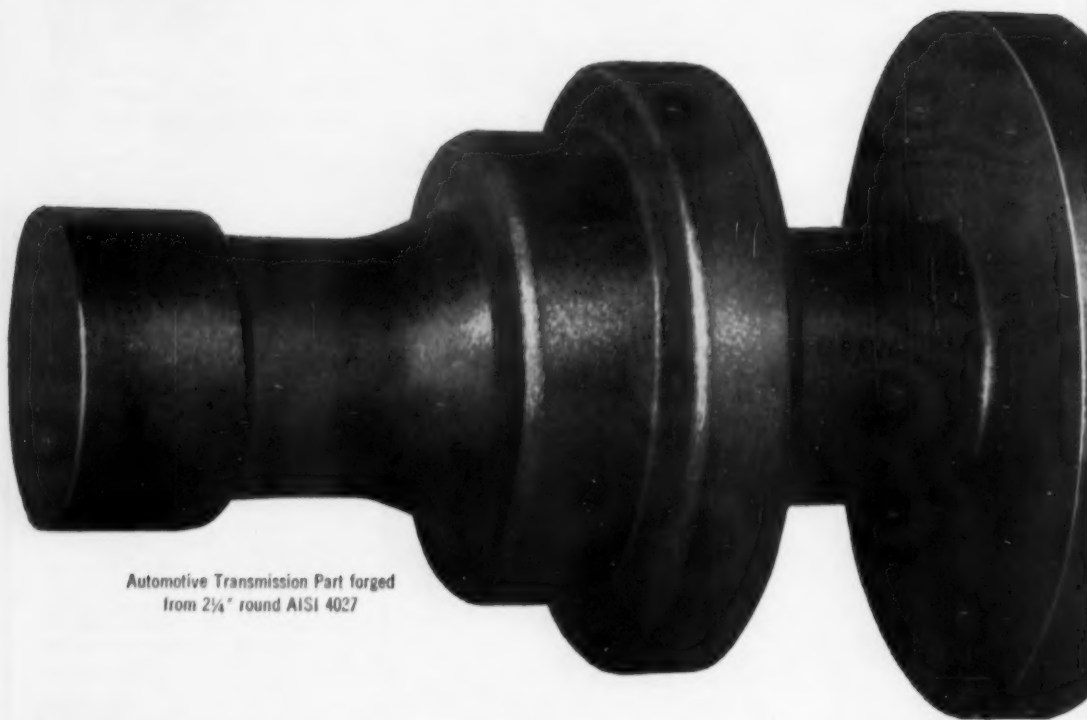
Described in Bulletin 320

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## Forging Quality Steel Bars

For high-quality forgings at low production costs you need forging steels with the right balance of machinability, forgeability and heat treating properties in carbon and alloy grades.

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J & L FORGING STEELS—EXACTLY TO SPECIFICATION

# Jones & Laughlin

STEEL CORPORATION • PITTSBURGH

on physical and electrical specifications for various sizes. *Globar Div.*

#### 1097. Heating Time Calculator

Slide chart gives heating time in salt baths for steel sections of different diameters. *Ajax Electric*

#### 1098. High-Alloy Assemblies

4-page folder on various types of process equipment of heat and corrosion resistant alloys. *General Alloys Co.*

#### 1099. High-Strength Steels

29-page discussion of progress being made toward higher strength alloy steels. Methods which increase strength of nickel-chromium-molybdenum alloy steel. *International Nickel Co.*

#### 1100. High-Temperature Alloy

Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

#### 1101. High-Temperature Alloy

14-page bulletin on Udimet 500 gives composition, heat treatment, machinability, hot working characteristics and properties. *Utica Drop Forge and Tool*

#### 1102. High-Temperature Alloy

"Haynes Alloys for High-Temperature Service" summarizes all available data on 10 superalloys and lists physical and mechanical properties of two newly developed alloys. *Haynes Stellite*

#### 1103. High-Tensile Steel

Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

#### 1104. Humidity Instruments

New 22-page bulletin on indicating, recording and controlling wet and dry bulb instruments and psychrometers. *Bristol Co.*

#### 1105. Hydrogen Atmosphere

Bulletin on equipment for supplying hydrogen with oxygen content less than one part per million and dew point to -70° F. *Baker & Co.*

#### 1106. Induction Brazing

Folder tells how tips of carbide may be brazed on tool shanks. *Ohio Crankshaft*

#### 1107. Induction Hardening

Bulletin M-1938 on induction hardening machine gives advantages and application of system. *Cincinnati Milling Machine*

#### 1108. Induction Heating

Catalog on Kilotron high frequency induction heater. *Electric Arc, Inc.*

#### 1109. Induction Heating

New 36-page bulletin on high-frequency induction heating unit for brazing, hardening, soldering, annealing, melting and bombarding. *Lepel*

#### 1110. Induction Heating

New 12-page bulletin gives descriptions, technical data on various sizes. Water systems diagrams and standard accessory equipment. *High Frequency Heating Div., Lindberg Engineering*

#### 1111. Induction Heating

12-page bulletin B-6519 on motor generator sets, r.f. generators, work stations, handling equipment. *Westinghouse Electric*

#### 1112. Induction Heat Control

New Bulletin HT-1 on automatic temperature control for induction heating equipment. Types of control, components of induction heaters. *Minneapolis-Honeywell*

#### 1113. Industrial Ovens

New 36-page catalog shows range of ovens designed for various uses such as machine tool finishing, paint baking and others. *Kirk & Blum*

#### 1114. Inspection

Descriptive information and instructions

for new inspection process to detect surface flaws on all ferrous and nonferrous metals. *Zaco Laboratories*

#### 1115. Insulation

New 20-page catalog on thermal insulations and refractories for application at -400° F. to +3000° F. Composition, physical and thermal properties. *John-Manville*

#### 1116. Investment Casting

12-page brochure on the process, shapes which may be cast, tolerances, assembly savings. *Investment Casting Co.*

#### 1117. Laboratory Equipment

Data sheets on three models of Projecta analytical projection balances and balance table. *C. A. Brinkman & Co.*

#### 1118. Laboratory Furnace

Box furnace with cooling chamber for use to 3100° F. described in bulletin GEA-4713. *General Electric*

#### 1119. Laboratory Mill

4-page reprint on rolling mill for laboratory studies, which may be operated as a 2-high, 3-high or 4-high mill. *Fenn Mfg.*

#### 1120. Laboratory Supplies

Instruments and apparatus for control, research, development laboratories. *Harshaw Scientific*

#### 1121. Leaded Steel

8-page bulletin gives chemical composition, mechanical properties and case studies showing machining production rates of lead bearing steel. *Ryerson*

#### 1122. Low-Carbon Stainless

"Melting Low-Carbon Stainless Steel" shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

#### 1123. Low-Temperature Brazing

Folder on brazing copper to nichrome, stellite to steel, brass to brass, steel to cast iron. *Handy & Harman*

#### 1124. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold forming, cold heading and other applications. Case histories. *Alpha Corp.*

#### 1125. Lubricants

Revised 4-page booklet on graphite, molybdenum disulfide, mica vermiculite, zinc oxide and acetylene black. Carriers, diluents, applications and physical data. *Acheson Colloids*

#### 1126. Machining Titanium

8-page bulletin on turning, milling, drilling, tapping, grinding. Recommendations for each. Typical properties of titanium. *Mallory-Sharon Titanium Corp.*

#### 1127. Marking Machines

26-page catalog of marking machines and tools. Production roll marking and bar stock speed markers described. *Noble & Westbrook Mfg. Co.*

#### 1128. Master Alloys

Bulletin on custom-made alloys for remelt or reprocessing. *Cannon-Muskegon*

#### 1129. Melting Furnace

Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg*

#### 1130. Metal Spraying

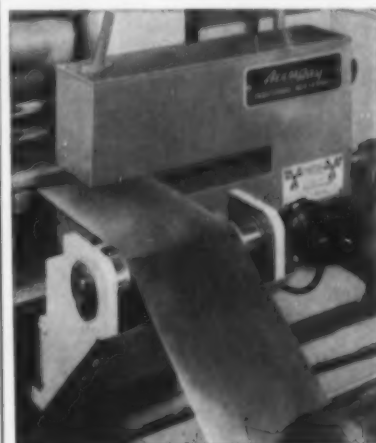
Folders on ThermoSpray gun for spraying powdered ceramics and metals without compressed air. *Metallizing Engineering Co.*

#### 1131. Metallographic Equipment

12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*



## UNIFORM AS THE ATOM



### Somers Thin Strip now Gauged by Nuclear Energy

To meet the increasing demands of electronics and other industries for uniform closer tolerances, Somers Brass has taken advantage of one of the latest developments in the electronic field by installing the first Accu-Ray gauges in the non-ferrous industry. These units make it possible to check and control thickness from edge to edge throughout each coil to a degree of accuracy never before known.

Accu-Ray gauging is typical of the modern methods Somers combines with engineering experience to provide thin strip metal to your most rigid specifications. Nickel, Monel, and Nickel Alloys from .020" to .00075". Brass, Bronze, Copper and Alloys from .010" to .00075".



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**A New, Wet Hand Grinder for  
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Individual elevated hard glass grinding surfaces are continually flushed with streams of water. This floats off the surface removal products, provides lubrication, and leaves sharp abrasive edges exposed at all times. A control valve permits complete selectivity of the volume of water. Ample drainage facilities with standard pipe fittings are provided at the rear. The grinding platforms are pitched downward and away from the operator.

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 Grits 240, 320, 400, 600 per 100...\$10.00

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# BUZZER

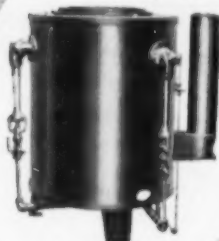
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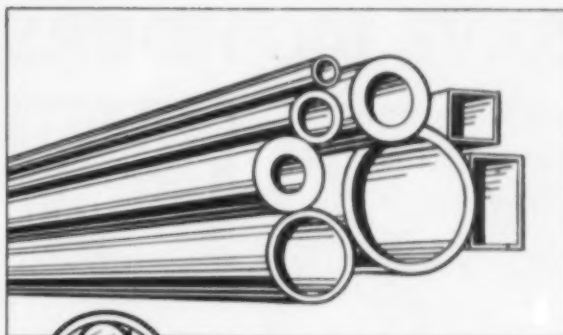
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BURNERS - FURNACES (Heat Treating, Melting, Soldering)

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.095" OD to 1.50" OD  
Stainless and Nickel Alloy  
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All cold drawn and bright annealed except special heating element tubes which are as welded and bright annealed.

Large stocks of raw material assure early shipping schedules.

## SMITH TUBE CORPORATION

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### 1132. Metallographic Polishing

AB Metal Digest discusses features of various models of metallographic polishing equipment. *Buehler, Ltd.*

### 1133. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

### 1134. Microscopes

8-page booklet No. 5 on research microscopes, stages, illuminators and other accessories. *American Optical*

### 1135. Microscopes

Catalog on metallograph and several models of microscopes. *United Scientific*

### 1136. Mo-Fe Castings

Bulletins 1 and 2 on molybdenum iron castings give advantages of molybdenum in these castings. *Climax Molybdenum*

### 1137. Moisture Measurement

12-page bulletin on how to measure water vapor in air and other gases. Gravimetric, dew point and wet and dry bulb methods, and others. *Pittsburgh Lector-dryer*

### 1138. Motion Pictures

12-page booklet gives five case histories showing how movies solved engineering problems. *Professional Goods Div., Eastman Kodak Co.*

### 1139. Nitriding

Data on process for nitriding stainless steel. *Standard Steel Treating*

### 1140. Nitriding Furnace

Bulletin 646R on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Hevi Duty*

### 1141. Nitrogen Generator

New 6-page bulletin No. 1-100 gives

flow diagram and explains operation. *C. M. Kemp Mfg. Co.*

### 1142. Nondestructive Inspection

8-page bulletin on use of ultrasonic Reflectoscope describes principles of ultrasonic inspection and its uses. *Sperry*

### 1143. Nondestructive Testing

8-page bulletin on equipment for non-destructive testing of bars, rods, tubing. *Magnetic Analysis*

### 1144. Nonferrous Melting

Bulletin 26-A on high-frequency furnaces for melting copper, silver, gold, platinum, aluminum and magnesium. *Ajax Electrothermic*

### 1145. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

### 1146. Oil Quenching

8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

### 1147. Openhearth

Brochure on modern openhearth design and construction. *Loftus*

### 1148. Ovens

16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl Mayer*

### 1149. Ovens

Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° F. *Young Brothers*

### 1150. Ovens

Bulletin 100 on laboratory and produc-

tion ovens. Engineering, construction and control features. *Despatch Oven*

### 1151. Paint Adhesion

New 6-page pamphlet on line of phosphating materials. Includes phosphating reference chart for solving paint adhesion problems. *Turco*

### 1152. Patterned Metal

6-page booklet on Roll-Bond, patterned metal for heat and cold transfer applications. How it is made and uses. *Western Brass Mills Div.*

### 1153. Photomicrography

Catalog E-210 on sliding base, high or low power photomicrographic equipment. *Bausch & Lomb*

### 1154. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

### 1155. Plating

New 8-page brochure on test equipment for plating baths. Controls, anodes, cathodes agitators, rectifiers described. *R. O. Hull & Co.*

### 1156. Plating Solutions

New 4-page bulletin on potassium cyanide describes its purity, handling, safety and quality control. *Koppers Co.*

### 1157. Plating Solutions

Operating manuals for plating with metal fluoborate solutions. *Baker & Adamson*. See page 199.

### 1158. Powder Metallurgy

12-page bulletin B-101 on furnaces for sintering powder metal products and reduction of metallic oxides. *Drever Co.*

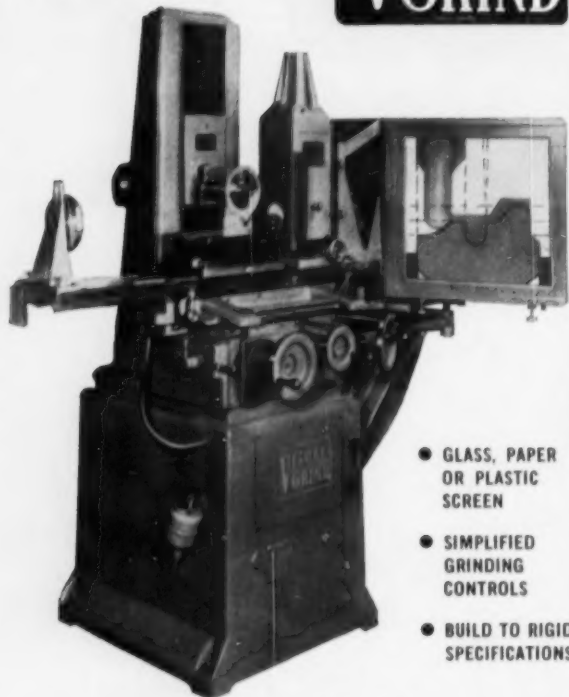
### 1159. Powdered Metals

New 24-page catalog 815 on 37 different (Continued on p. 48-A)

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WIRE-TYPE, PROTECTED  
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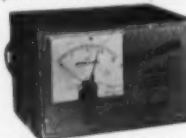
Like to know why? Here are some reasons: (1) It's accurate, (2) durable, (3) made in Copper Constantan, Iron Constantan, or Chromel Alumel, and (4) available with built-up protection tubes or drilled wells of various materials. Thermocouple illustrated has built-up stainless steel protection tube.

*T-E makes many thermocouples for almost any kind of temperature measurement. Interested? Write for bulletin 22—H.*

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For any variable that can be measured electrically.  
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Some of the present applications are: Monitoring milling cutters (a dull tool pulls more load); automatic pH alarm; photocell light detectors; battery charger control; control of vacuum in TV tube manufacturing; conveyor belt speed control; moisture content control or warning.

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West Coast: Desert Hot Springs 37, California

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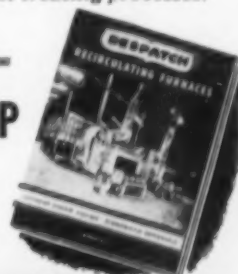
**Heat Process Control:** Despatch car bottom recirculating furnaces are designed to maintain the required uniformity regardless of the load size.

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**Great Flexibility:** Wide temperature range, large work area, car bottom batch loading make this furnace adaptable to many heat treating processes.

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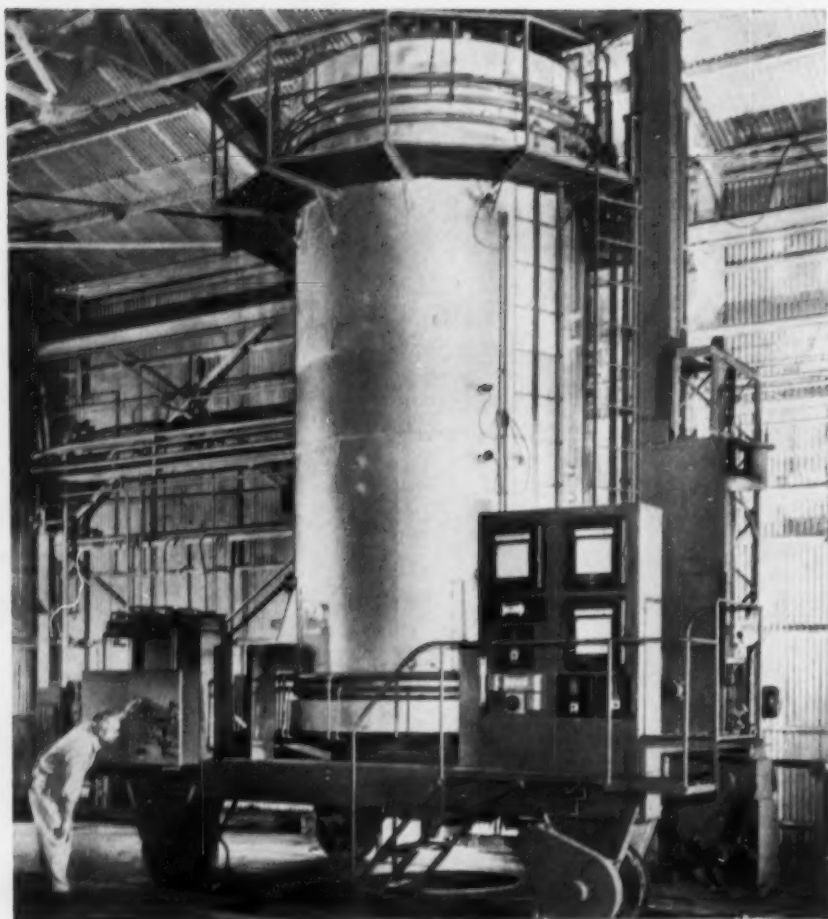
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*Resists wide variations of atmosphere and temperature in big Cal-Doran unit*

Here's a versatile, new, heat-treating facility for West Coast manufacturers . . . Cal-Doran's drop-bottom, car-mounted furnace.

It treats everything from long torsion bars to massive tool dies. Takes parts up to 16 feet long and 42 inches in diameter. Stress relieves, carburizes or solution anneals them. Hardens or tempers them. Restores carbon. Atmospheres and temperatures (up to 1900°F) are rigidly controlled.

Inconel® nickel-chromium alloy helps give this unit its versatility. For the work is done inside an

Inconel alloy retort. This shell is 1/8-in. thick, 48 inches in diameter, and supported by 16 1/4-in. diameter Inconel alloy hanger rods.

### Takes wide range of atmospheres, temperatures

Right now this retort is just over a year old. It's still in excellent condition. That's because Inconel alloy retains its high strength despite temperature ups and downs, long soaks. It has excellent resistance to thermal shock, too . . . and to every commonly used furnace atmosphere.

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Some of these applications . . . suggesting ways to use Inconel alloy profitably . . . have been photographically reported in an interesting Inco Booklet, "Keeping Costs Down When Temperatures Go Up." Write for a copy.

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67 Wall Street New York 5, N. Y.



**Nickel Alloys**

**Inconel . . . for high strength at high temperatures**

(Continued from page 45)  
models of powder metal presses. F. J. Stokes

#### 1160. Precision Castings

5-page folder on investment casting. Engineered Precision Casting

#### 1161. Precision Casting

New 16-page booklet on methods used to produce castings by the "lost wax" method. Compositions of alloys used. Crucible Steel

#### 1162. Pure Metals

Data sheets on vacuum melted cobalt, copper, iron and nickel. Vacuum Metals

#### 1163. Pyrometer Calibration

"Pyrometer Thermocouple Calibration Data" includes tables of data released by National Bureau of Standards. Bristol Co.

#### 1164. Quench Agitation

Information on mixers and agitators, including units applicable to industrial quenching equipment. Mixing Equipment

#### 1165. Quenching

64-page book tells what happens when steel is heated and cooled, describes quenching media, quenching practices, interrupted quenching and cooling methods. E. F. Houghton

#### 1166. Quenching

New catalog on two small self-contained quenching units. Bell & Gossett

#### 1167. Quenching

4-page booklet on continuous automatic quenching tanks. Specifications, construction. American Gas Furnace

#### 1168. Quenching

24-page booklet on agitation of quenching mediums. Engineering of agitator installations. U. S. Steel

#### 1169. Quenching Oil

New Bulletin 45 on quenching oil treats mechanism of quenching and explains how Sunquench 78 aids. Sun Oil

#### 1170. Quenching Oil

10-page book on new oils for the quenching process gives results of test and in operation. Sinclair Refining

#### 1171. Radiography

26-page brochure on very high voltage equipment for radiography and how it is used. High Voltage Engineering

#### 1172. Rare Earths

Folder on high-purity rare earths gives their properties and properties of oxides. Uses. St. Eloi Corp.

#### 1173. Rare Earths

8-page Progress Report Number 1.

"Rare Earths in Iron and Steel Melting". Molybdenum Corp.

#### 1174. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. Lumnite Div.

#### 1175. Resistance Welding

24-page catalog on equipment for resistance welding includes reference tables and property and application charts. Ampco

#### 1176. Resistance Welding

56-page catalog of resistance welding products, accessories and materials. Selection of alloys and electrode materials. Weldaloy Products Co.

#### 1177. Rust Preventives

12-page bulletin on water-soluble rust preventive. Production Specialties

#### 1178. Rust Removal

Folder on new alkaline cleaning material for removal of rust, certain types of heat scale and metallic smuts. Oakite

#### 1179. Salt Bath Carburizing

5-page booklet on liquid carburizing with advantages and disadvantages of the salt bath process. American Cyanamid Co.

#### 1180. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. Upton

#### 1181. Salt Bath Furnaces

Reprint No. 145 on basic principles of electrode type salt bath furnaces gives methods of mechanization and applications. Ajax Electric

#### 1182. Saws

Catalog C-53 describes 35 models of metal-cutting saws. Armstrong-Blum

#### 1183. Seamless Welding Fittings

Bulletin FB-502 on carbon, alloy and stainless seamless welding fittings and forged steel flanges. Babcock & Wilcox

#### 1184. Selective Carburizer

Bulletin on "No-Carb" for selective carburizing and prevention of decarburizing on high alloy steels during heating for hardening. Park Chemical

#### 1185. Sheet Feeder

New 6-page brochure on 150-sheet per minute metal sheet feeder. Operating features and specifications. Dexter Folder

#### 1186. Shotblasting

16-page "Primer on the Use of Shot and Grit". Problems of blast cleaning operations. Hickman, Williams

#### 1187. Slitting

76-page book on slitting lines for coils and sheets. Design, selection, operation, time studies of operating cycle. Yoder

#### 1188. Sodium

28-page booklet on using sodium in dispersed form tells how dispersions are prepared and handled, and their advantages. Ethyl Corp.

#### 1189. Spectrographic Supplies

24-page catalog on special pure materials and alloy standards, plates and films, graphite electrodes and powders. Jarrell-Ash

#### 1190. Spot Welding

Bulletin 339 on spot welder with predetermined electronic control. Circuits employed. Sciaky Bros.

#### 1191. Stainless Castings

Bulletin on advantages of corrosion-resistant castings. Ohio Steel Foundry

#### 1192. Stainless Steel

Two booklets on 200 series of low nickel, austenitic stainless steels, give applications and properties compared with 300 series. Republic Steel

#### 1193. Stainless Steel

Booklet on 430 stainless. Properties, fabrication. Sharon Steel

#### 1194. Stainless Steel

20-page catalog on corrosion resistance, applications and working characteristics of 20% chromium-29% nickel stainless steels, with and without columbium. Carpenter Steel

#### 1195. Stainless Steel

12-page booklet on new AM 350 chromium-nickel-molybdenum stainless steel which is hardenable by subzero cooling or double aging. Allegheny Ludlum

#### 1196. Stainless Strip

32-page brochure on 20 types of stainless strip steel. Recommended applications, chemical, physical and mechanical properties. Superior Steel Corp.

#### 1197. Stainless Tubing

40-page catalog, section 20, on alloys used, fabrication and working, pickling process. Sections on welding, soldering, brazing, machinability. Superior Tube

#### 1198. Steel 52100

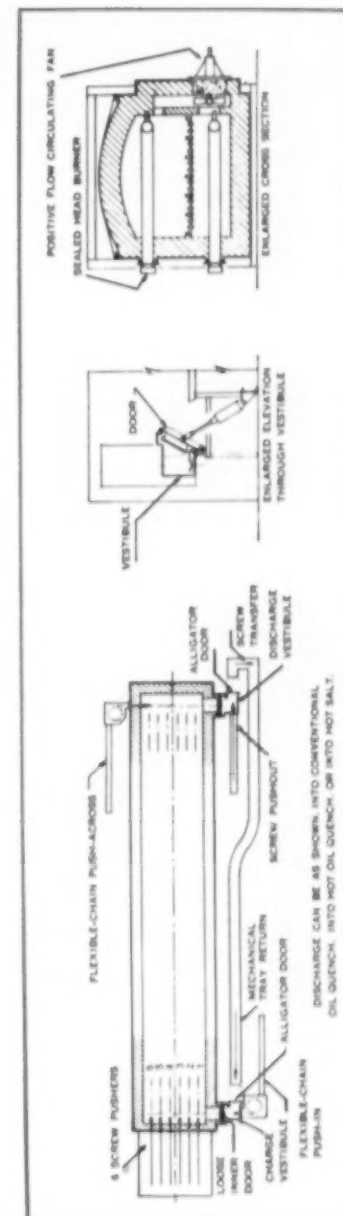
New stock list on 52100 tubing, bars and ring forgings. Peterson Steels

#### 1199. Steel Terms

32-page dictionary of terms used in the steel industry. 180 definitions. Equilibrium diagrams, tables and figures. LaSalle Steel

#### 1200. Steelmaking

Carbon and Graphite News for June 1956 tells how specialty steels are made in an electric arc furnace in 99 hr. from order to finished product. National Carbon



## LET'S TALK THE LATEST IN FURNACE DESIGN

Visualize six rows of stock — each row may be of a different size and shaped part and may move at a different rate of speed through the furnace. That's real versatility!

This is the nutshell story of a new Holcroft design. Here are more facts:

**HEATING**—Sealed head radiant tube burners heat the installation. Air and fuel are metered and progressively mixed as they pass through the tubes providing maximum efficiency at all rates of heating. A positive flow circulating fan assures even distribution of heat and atmosphere around the work.

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Used with the Lo-Dew gas generator, a wide variety of processing (carbo nitriding, carburizing, clean hardening, carbon restoration, etc.) can be handled.

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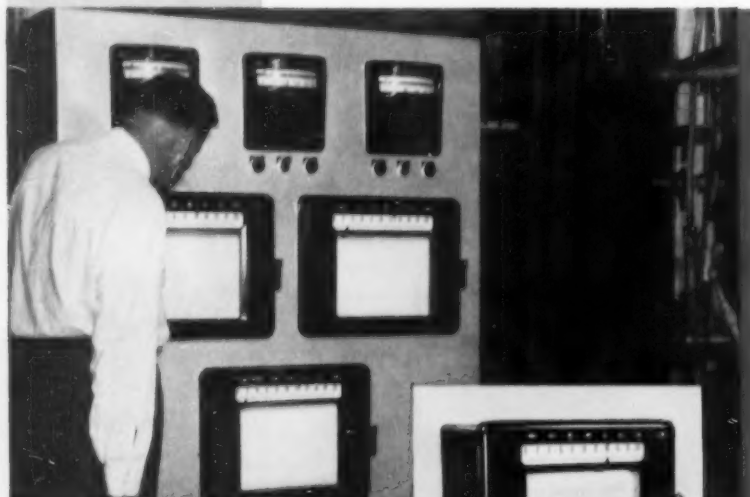


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Wheelco 8000 Series Recorders on 35 ft long, 3-zone continuous-type G.E. electric furnace in a large Midwestern heat-treating plant. Wheelco Limitrols at top. Furnace capacity, 1000 lb per hour.

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Aircraft Controls • Small Motors • Overdoors and Operators • Molded  
Products • Metal Cutting Tools • Machine Tools • Textile Machinery

### 1201. Sub-Zero Treatment

New 12-page booklet on industrial chilling equipment for shrinking, testing and treating of metals. Cincinnati Sub-Zero Products

### 1202. Temperature Control

Facts folder on Magamp link units for proportional temperature control systems. Westinghouse Electric

### 1203. Test Bars

18-page bulletin No. 168 on design of test bar patterns, production of test bars, testing procedures. Federated Metals Div., American Smelting and Refining

### 1204. Test Specimens

Data on machine for cutting test specimens to ASTM specifications. Sieburg Industries

### 1205. Testing Machines

24-page Bulletin 47 on complete line of Super-L universal testing machines. Indicating systems, loading systems, diagrams of various machines. Tinius Olsen Testing Machine Co.

### 1206. Testing Machines

8-page guide to Riehle testing machines and instruments. Riehle

### 1207. Thermocouple Alloys

20-page booklet on chromel-alumel alloys gives sizes, temperature-millivolt equivalents, standards, applications. Hoskins Mfg.

### 1208. Thermocouple Data

New bulletin F-5228-3 on construction and application of thermocouples and radiation detectors to industrial control. How to check, make, select and size thermocouples. Wheelco

### 1209. Thermocouple Insulators

New Bulletin No. 300-56 on complete line of thermocouple insulators. Dimensions, sizes, types of insulators. Claud S. Gordon

### 1210. Thermocouple Restorer

New catalog R-27 on device for renewing proper electrical conductivity through thermocouples and thermocouple circuits. Peerless Electric Co.

### 1211. Thermocouples

New 10-page bulletin 2 on miniature bayonet thermocouples. Instructions on selection. Calibrations and ranges. Thermo Electric Co.

### 1212. Thermocouples

36-page Bulletin 19-10 describes various types of thermocouples, extension wire and other accessories. Foxboro

### 1213. Thermocouples

20-page Bulletin 714 on thermocouples, protecting tubes and wells, insulators, leads, connectors, heads. Gen. Electric

### 1214. Thickness Testers

6-page catalog on Audigage thickness testers. Characteristics and applications of five models. Branson Instruments

### 1215. Tin News

Interesting monthly report covers important current developments in the production, marketing and use of tin. Malayan Tin Bureau

### 1216. Tool Steel

44-page stock list is indexed and includes sizes, weights, and analyses. Decimal conversion and hardness conversion tables. Uddeholm

### 1217. Tool Steel

Fourth edition of the 204-page handbook. Types, properties and applications of tool steels. Selection, tool steel products, working tool and high speed steels. Allegheny Ludlum Steel Corp.

### 1218. Tool Steel Heat Treat

Bulletin 1147EE on electric furnace for heat treatment of high speed tool steel. Hevi Duty

### 1219. Tool Steels

Data on air-hardening hot work die steel for forging. Ziv Steel & Wire Co.

### 1220. Tumbling

8-page booklet on precision tumbling, a controlled-motion honing process for parts which could not previously be finished by tumbling. BMT Mfg. Corp.

### 1221. Tungsten

32-page book gives applications of tungsten, types of ore, mining. Tungsten Institute

### 1222. Tungsten

20-page bulletin on manufacture, properties and uses of tungsten. Flow chart of tungsten production. Sylvania Electric Products

### 1223. Ultrasonic Testing

Data folder describes instruments using ultrasonics for various tests—immerscope, "B" scan and flaw recorder. Curtiss-Wright

### 1224. Vacuum Calculator

Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. F. J. Stokes Machine

### 1225. Vacuum Gages

32-page Catalog 7001 on gages for vac-

uums to 10<sup>-11</sup> mm. Hg and pressures to 150,000 psi. Minneapolis-Honeywell

### 1226. Vacuum Metallurgy

Information memo tells of materials handling in vacuum metallurgy. Consolidated Vacuum

### 1227. Vacuum Metallurgy

Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. National Research

### 1228. Vanadium Tool Steels

12-page booklet gives properties, heat treatment, effect of tempering, hardenability of chromium-vanadium tool steels. Vanadium-Alloys Steel

### 1229. Welders

New 6-page bulletin on magnetic force welders. Advantages in welding difficult critical materials. Precision Welder and Flexopress Corp.

### 1230. Welding

Data card 155A tabulates arc welding procedures for various types of tubing. Babcock & Wilcox

### 1231. Welding Electrodes

Report No. W5410 on low hydrogen electrodes for high alloy steels. Harnischfeger

### 1232. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. Erico Products

### 1233. Wire

New wire catalog on wire, ribbon, weld and carbostrip products. Wire includes alloy, clad and plated. Sylvania Electric Products, Parts Div.

### 1234. Wire Cloth

84-page booklet on applications, meshes, baskets, filters. Cambridge Wire Cloth

### 1235. X-Ray

12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. Picker X-Ray

### 1236. X-Ray Diffraction

New 4-page bulletin on X-ray diffraction for research, production control. Two units described. General Electric, X-Ray

### 1237. X-Ray Supplies

50-page catalog of industrial X-ray supplies and accessories. Westinghouse

### 1238. Zirconium

New 18-page pocket-sized book on manufacture, properties, metallography, machining, metal powders. Extensive bibliography. Titanium Alloy Mfg. Div.

OCTOBER, 1956

957	982	1007	1032	1057	1082	1107	1132	1157	1182	1207	1232
958	983	1008	1033	1058	1083	1108	1133	1158	1183	1208	1233
959	984	1009	1034	1059	1084	1109	1134	1159	1184	1209	1234
960	985	1010	1035	1060	1085	1110	1135	1160	1185	1210	1235
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963	988	1013	1038	1063	1088	1113	1138	1163	1188	1213	1238
964	989	1014	1039	1064	1089	1114	1139	1164	1189	1214	
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969	994	1019	1044	1069	1094	1119	1144	1169	1194	1219	
970	995	1020	1045	1070	1095	1120	1145	1170	1195	1220	
971	996	1021	1046	1071	1096	1121	1146	1171	1196	1221	
972	997	1022	1047	1072	1097	1122	1147	1172	1197	1222	
973	998	1023	1048	1073	1098	1123	1148	1173	1198	1223	
974	999	1024	1049	1074	1099	1124	1149	1174	1199	1224	
975	1000	1025	1050	1075	1100	1125	1150	1175	1200	1225	
976	1001	1026	1051	1076	1101	1126	1151	1176	1201	1226	
977	1002	1027	1052	1077	1102	1127	1152	1177	1202	1227	
978	1003	1028	1053	1078	1103	1128	1153	1178	1203	1228	
979	1004	1029	1054	1079	1104	1129	1154	1179	1204	1229	
980	1005	1030	1055	1080	1105	1130	1155	1180	1205	1230	
981	1006	1031	1056	1081	1106	1131	1156	1181	1206	1231	

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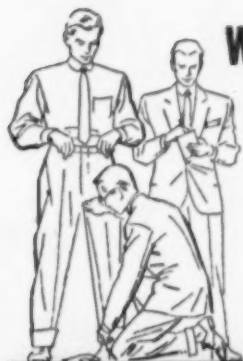
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Company \_\_\_\_\_

Address \_\_\_\_\_

City and State \_\_\_\_\_

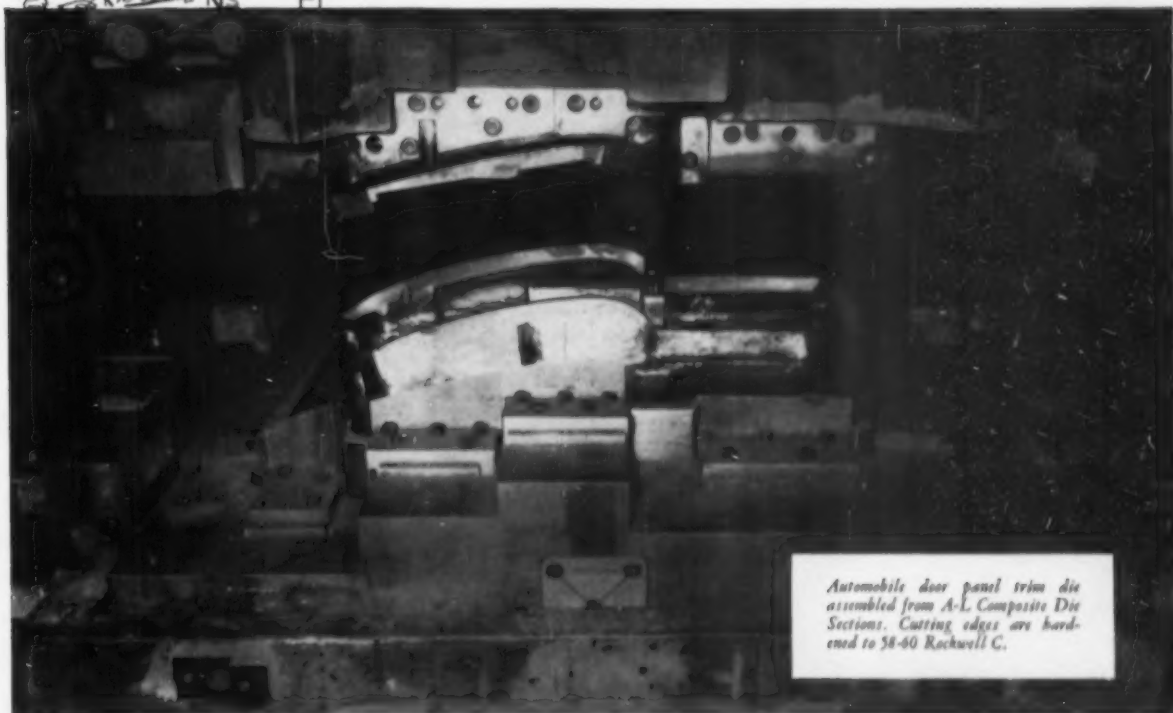
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Dies can be assembled from A-L Composite Die Sections to blank, trim, bead or do any job requiring the cutting of sheet metal to regular or irregular shapes. Thousands of die shapes are possible from combinations of the thirty-five standard sections carried in stock. Thus, you save the time and trouble of machining custom-made sections from solid stock and minimize the waste of valuable tool steel.

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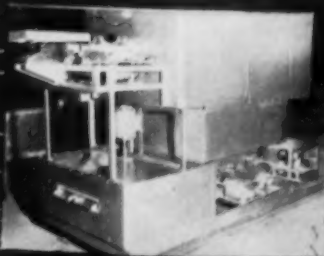
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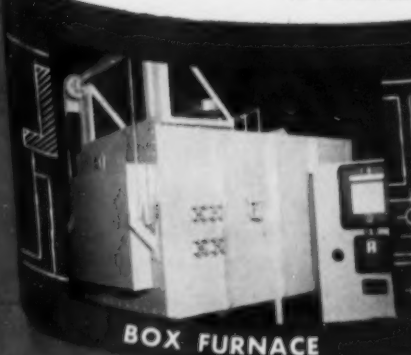
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GAS GENERATOR



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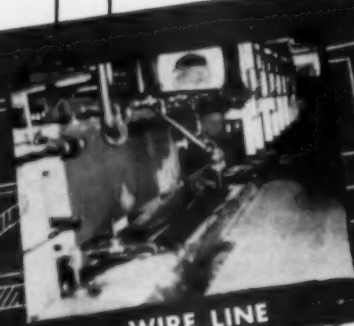
BELT FURNACE



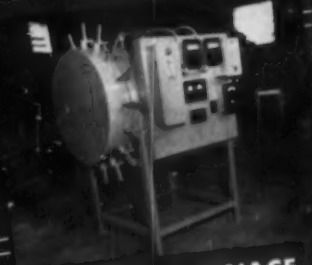
LARGE UNITLINE



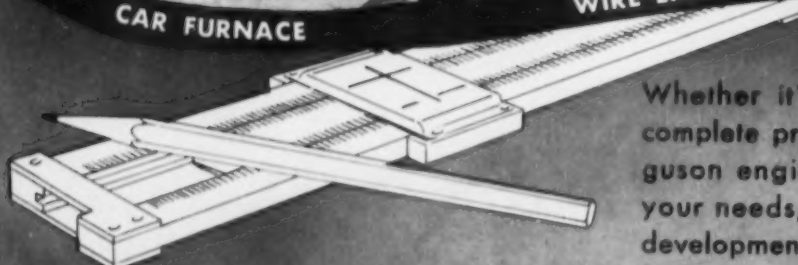
CAR FURNACE



WIRE LINE

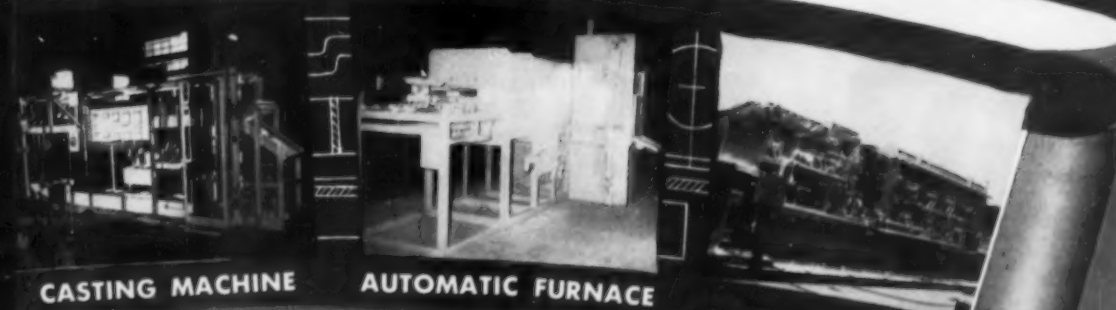
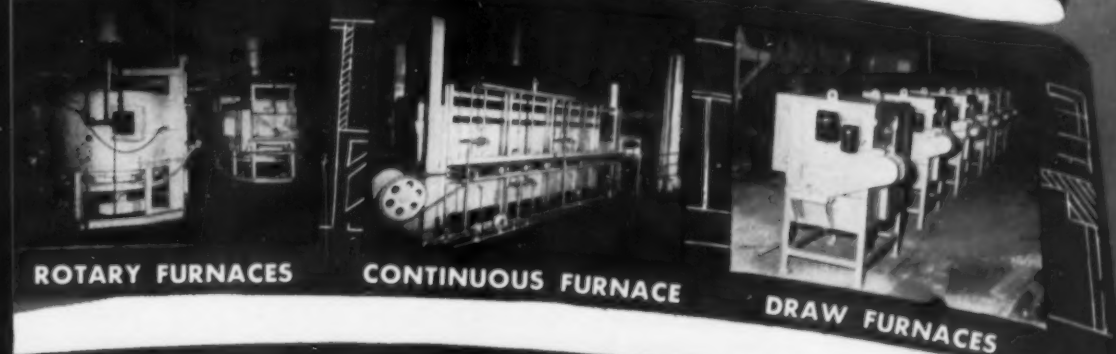


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Whether it's a single furnace or a complete production line, have a Ferguson engineer check and analyze your needs, with respect to the new developments which we have to offer.

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# Now! CHANGE SUBMERGED ELECTRODES IN AN HOUR!

... without disturbing furnace casing or pot  
... at substantial savings of labor, material and time

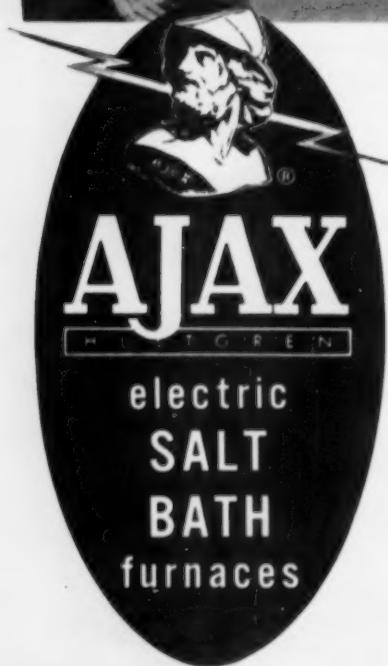


1 Just hoist the removable tile covering ...

SEE IT AT  
THE SHOW!  
Ajax Booth 1609  
(in the Arcade)



2 Electrodes are now completely accessible for fast changing.



In this unique new Ajax Electric Salt Bath\*, electrodes enter the furnace from over the top, yet retain

all the favorable characteristics of the submerged design. They are replaced by hoisting a removable tile, putting in new ones and setting the tile back in place.

It's as simple as that! No need to disturb either the pot or furnace casing. "Down time" is held to an absolute minimum. Salt is saved. Spare casings are no longer required. A complete electrode change takes about an hour per pair. Often, the change can be accomplished before the molten salt can solidify.

Write for bulletin giving details of this revolutionary design feature for either new or old Ajax Electric Salt Bath Furnaces.

## ALL THE ADVANTAGES OF COMPLETELY SUBMERGED ELECTRODE DESIGN!

The removable tile covering seals the electrodes against air, thus giving all the advantages of submerged design including protection against oxidation at the salt line. Life of new type Ajax electrodes using no critical materials compares more than favorably with that of conventional nickel alloy electrodes in conventional-electrode furnaces.

\*Patent Pending

## AJAX ELECTRIC COMPANY

910 FRANKFORD AVENUE, PHILADELPHIA 23, PA.

Associate Companies: Ajax Electric Furnace Corporation

• Ajax Engineering Corporation

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## now, Crucible low nickel stainless steels that meet many of your needs...

Here are two *new* Crucible grades, Rezistal type 201 and 202 that are similar in quality and properties to types 301 and 302... but with desirable features all their own.

In the annealed condition, for example, Rezistal 201 and 202 have about 10% higher strength than 301 and 302, yet maintain almost identical ductility. This means that these grades can be fabricated with ease equal to their counterparts. In addition, their mill finishes and corrosion resist-

ance to a wide variation of media compare most favorably with 301 and 302.

To sum up: Rezistal 201 and 202 have practically all the desirable properties of 301 and 302, *plus* some of their own. And they're available *promptly* in all forms. Write now for data sheets fully covering the properties of these new stainless grades. *Crucible Steel Company of America, Dept. AMP, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

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first name in special purpose steels

### **Crucible Steel Company of America**

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Please send me brochure on Sodium Hydride Descaling describing its uses, advantages, typical reactions and necessary equipment.

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MP-10-56

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If your products call for aluminum tube, it will pay you to put your requirements up to Revere. For at this one source you can obtain virtually any aluminum tube you want . . . seamless drawn, welded, lockseam and others; in an extensive range of sizes, alloys and tempers; both round and other-than-round.

Revere has the men, machines and experience to produce tube that is right for its purpose as well as right on schedule. It will pay you to tie the progress of your business to the most dependable sources of supply. Call the nearest Revere Sales Office now. In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801. Executive Offices: 230 Park Avenue, New York 17, N. Y.

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# TUBE

Facts to consider when you're buying

# Chromate Conversion Coatings

## for Corrosion Protection, Paint Base, Decorative Finishing

### WHAT IS IRIDITE?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a nonporous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

If your company is manufacturing or buying parts or complete assemblies made from or plated with any of the more common non-ferrous metals—zinc, cadmium, aluminum, magnesium, silver, copper, brass or bronze—you've probably already run up against the question of finishing these surfaces with a chromate conversion coating. These coatings are used to protect against corrosion, or to provide a base for paint or to provide a decorative finish for sales appeal or shelf life. Since chromate conversion coatings represent a relatively new means of obtaining these finishes, this digest of facts to consider may be of value to you.

#### 1. THE COATINGS THEMSELVES.

There are many brands on the market. All are similar in many ways. Each, of course, offers its own specific advantages and these may relate to operating techniques, performance under actual use conditions, cost, availability, etc. Naturally, you'll want to choose a coating that is widely known and accepted under both military and civilian specifications.

#### 2. THE COMPANY BEHIND THE PRODUCT.

Is it a reliable, established organization? Does it offer experienced technical service, both from the field-engineering organization as well as the home office and laboratories? The man who sells and services your installation should be thoroughly familiar with not only chromate conversion coatings and their applications, but also with the characteristics and performance of related finishing operations such as pre-cleaning, electroplating, painting, etc. This is most important since all steps of the finishing cycle must be functioning properly for the satisfactory performance of the ultimate finish produced.

#### 3. AVAILABILITY OF THE PRODUCT.

Ideally, of course, the material should

be readily available to you from nearby warehouses to avoid time loss in long distance shipping and to provide emergency service, should the need arise.

**4. COST.** Naturally, the initial price of the material is important to you. However, just as you consider ultimate cost when you are buying mechanical equipment, ultimate cost must be considered for these finishing chemicals. So, it will pay you to investigate consumption costs, labor costs and the other factors which go into the determination of ultimate cost. Further, cost alone gives no indication of product performance, so careful attention must be given to the purpose the finish must serve and the value that finish will add to your product.

**5. FACILITIES FOR RESEARCH AND DEVELOPMENT.** Perhaps the existing types of chromate conversion coatings do not include a compound that will accomplish exactly what you wish. Then, it is important to deal with a supplier who has adequate research and development facilities available to work with you to produce a material to meet your needs. Naturally, such a project is seldom completed overnight. But, with complete cooperation and confidence from both you and your supplier, chances are a satisfactory program can be completed.

These are the concepts of sales and service on which we, Allied Research

Products, Incorporated, have developed and marketed the line of Iridite chromate conversion coatings...superior product performance, complete sales and technical service, easy product availability, economical cost, extensive research and development facilities. No doubt you are familiar with our line and have seen this trademark—

## IRIDITE®

—in our advertising, technical literature or on shipping containers in your plant. Remember this trademark when you're buying or investigating chromate conversion coatings for your company. It's your assurance of quality, economical products from a reliable and established company, skilled sales and technical service from both our home office and a national network of representatives, immediate availability from warehouses in strategic industrial areas and our willingness to work with you to develop new finishes to meet your needs, should the present line fall short.

For complete information on Iridite chromate conversion coatings, write today for your free copy of our technical data file. Or, for immediate advice, call in your Allied Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

### ALLIED RESEARCH PRODUCTS

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Manufacturers of Iridite chromate conversion coatings for corrosion resistance, paint systems, final finishing of non-ferrous metals; ARP Plating Brightener & Chemicals. West Coast Licensee—L. H. Butcher Co.

## New Fair Lawn Facilities

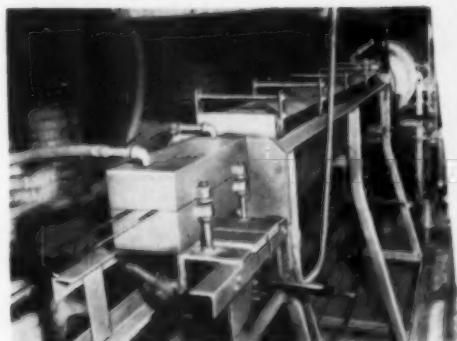
### Expand SANDVIK Service

### In "Custom-Tailoring"

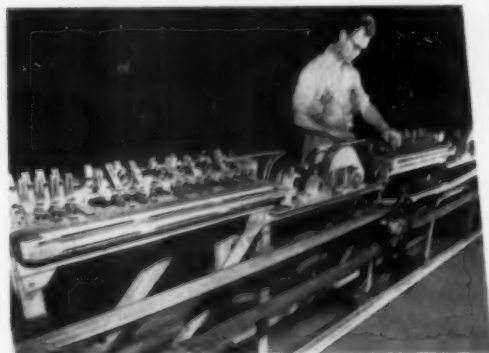
## QUALITY SPRING STEELS



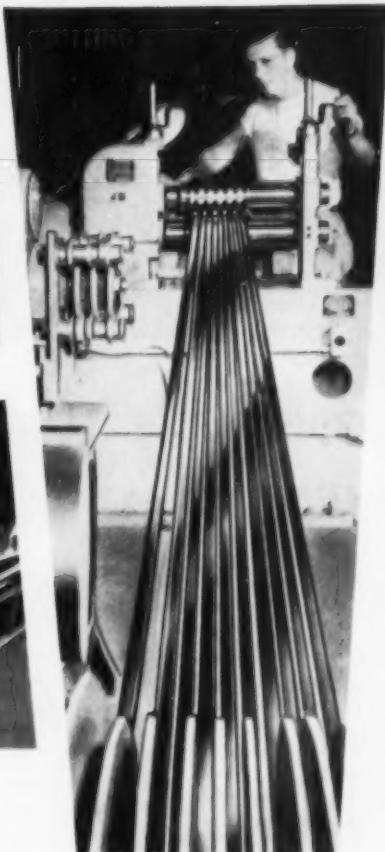
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*You can get Sandvik cold rolled specialty strip steels:*

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- Polished bright, yellow or blue.
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SS-114



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**Delivery when promised . . . dependability in every piece  
 . . . and economically produced in stainless steel  
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Not every shipment is as diversified as GOC 17656 but it illustrates the typical all-around service in stainless steel available from G. O. Carlson, Inc.

There are plates, heads, rings, circles, flanges, bars and rounds—all stainless steel to chemical industry standards—all made to match the specifications on the customer's blueprint. It took special equipment to make up this order—equipment designed and built by Carlson engineers who work exclusively in stainless.

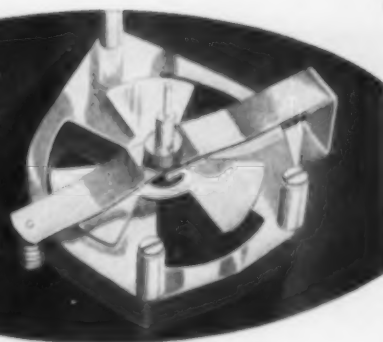
This equipment in the hands of Carlson specialists lowers costs. You pay no freight on

material you can't use and you save man-hours in easier fit-up, because the material is ready for fabrication when you get it.

When you order your stainless steel from G. O. Carlson, Inc. you can be sure of three things: (1) it is economically produced from the highest quality material; (2) it is cut to your specifications; (3) it is shipped on time. Write right now for complete information.

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In DYNALOG Instruments, a simple, variable, radio-type capacitor replaces the troublesome slide-wire — gives unmatched smoothness of balancing.



*This potentiometer has no slidewire*

**STEPLESS  
CAPACITY-BALANCING  
ELIMINATES  
SLIDEWIRE  
MAINTENANCE**

There's no need to put up with worn slide-wires and sticking electrical contacts . . . no need to periodically clean and lubricate balancing motors. DYNALOG design eliminates all this! Its simple variable capacitor and positive magnetic drive provide *continuous, stepless* balancing . . . *never* require attention!

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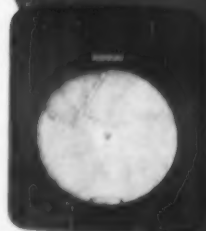
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recording pen!) Sensitivity, unlimited by turns of slidewire winding, is 1/100 of 1%. And accuracy is a sustained 1/4 of 1%.

DYNALOG Instruments are available for use with resistance, voltage, capacity, or inductive type primary elements to measure and/or control any process variable . . . with unmatched smoothness. Write for Bulletin 5210. The Foxboro Company, 524 Neponset Ave., Foxboro, Mass., U.S.A.

**DYNALOG'S\*  
EXCLUSIVE  
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- no slidewire
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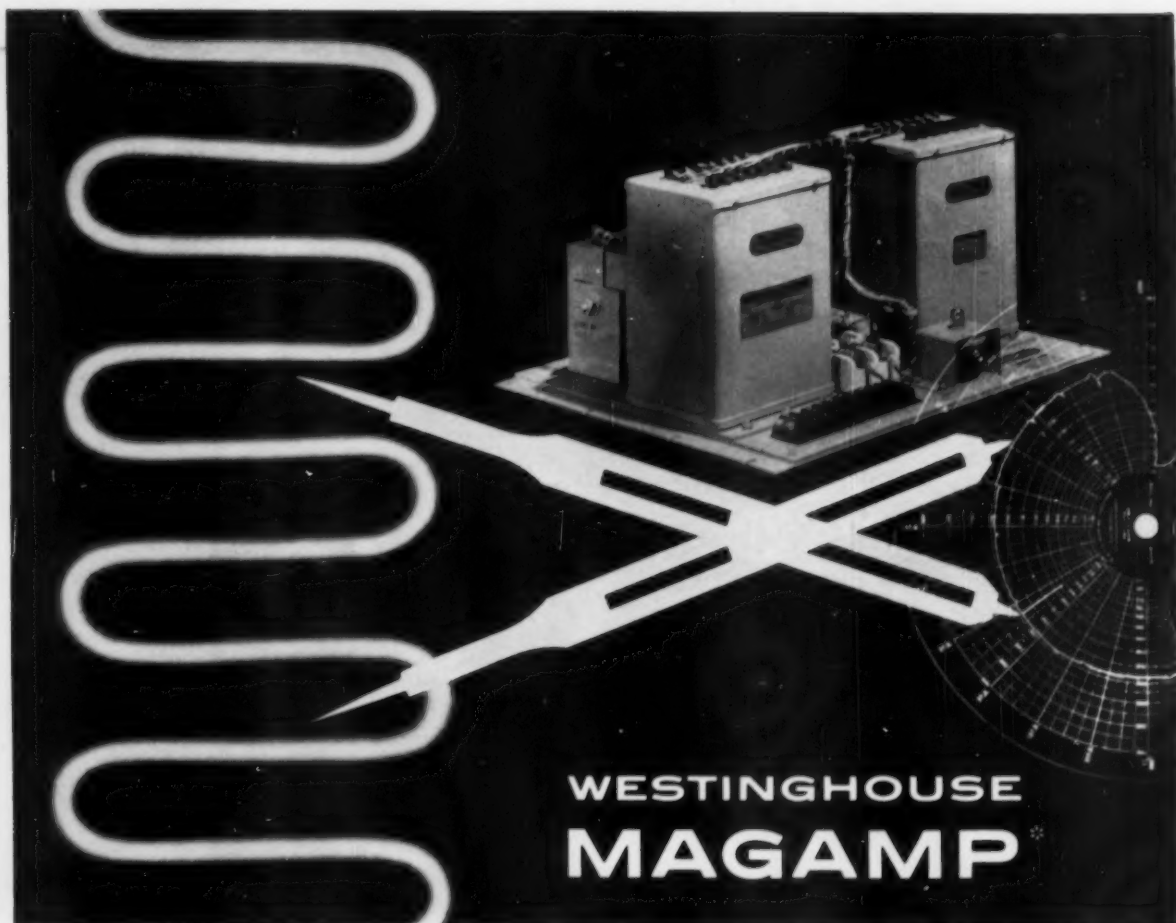


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**DYNALOG**

ELECTRONIC  INSTRUMENTS



## **Cuts proportional temperature control costs up to 50%!**

Westinghouse MAGAMP\* link units, magnetic amplifier panels, give you proportional temperature control systems with unusual savings in both first cost and operating costs.

MAGAMP link units are available in standard panel assemblies for industrial furnace control regardless of size. On such applications, they offer first-cost savings of up to 50% over conventional temperature control signal amplifiers. Savings in lifetime costs are even more significant.

MAGAMP link units are rated for at least ten times longer, trouble-free service than present-day electronic control. They are unaffected by heat, dirt or corrosive atmospheres and have no moving parts to stick or jam. Thus, you can eliminate costly maintenance and replacement expense.

\*Trade-Mark  
J-01007

**Free Facts Folder.** Contact your local Westinghouse sales engineer for all the facts, ratings and application data for standard MAGAMP link units; or write: Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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## Uses of Aluminum in Alloy Steels

Aluminum as an element has been known to chemists and metallurgists for many years. It is never found in nature in its metallic state, being derived chiefly from bauxite, an aluminum hydroxide. Bauxite is present in various parts of the world, including several tropical and semi-tropical regions.

When used in the making of alloy steels, aluminum has several important functions. Because of its great affinity for oxygen, it is a reliable deoxidizer. It produces fine austenitic grain size. And when it is present in amounts of approximately 1 pct, it promotes nitriding. The nitriding process could be described as surface- or case-hardening by means of a nitrogenous medium, or by heating in an atmosphere of ammonia gas and dissociated ammonia mixed in proper proportions.

Other effective agents in producing nitrided cases are chromium, vanadium, tungsten, and molybdenum. As a rule, however, the hardest cases are obtained with aluminum-bearing steels, the nitriding grades being a good example. These are usually steels of medium carbon content with additions of chromium, molybdenum, and sometimes nickel.

Generally speaking, the lower the

effective nitriding temperature, the harder the case will be. Aluminum-bearing steels usually show a case-hardness range of 950 to 1150 DPHN (diamond pyramid hardness number). Steels in which no aluminum is present have cases of substantially lower hardness.

If you would care to know more about aluminum as an addition or alloying agent in steels, Bethlehem metallurgists will gladly give you full information. Just write or call us; our technicians are always at your service. They will do everything possible to help make your problems easier. And whenever you need new supplies of alloy steels, remember that Bethlehem manufactures the full range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades.

*If you would like reprints of this series of advertisements from No. I through XVI inclusive, please write to us, addressing your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa. The first 16 topics are now available in a convenient 32-page booklet, "Quick Facts About Alloy Steels," and we shall be glad to send you a free copy.*

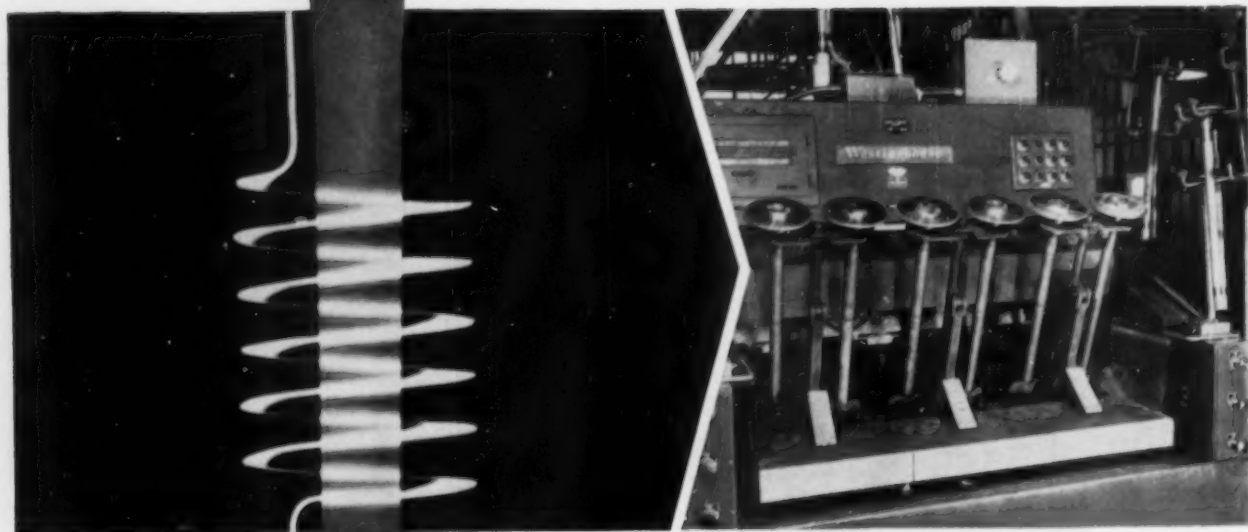
BETHLEHEM STEEL COMPANY  
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**BETHLEHEM STEEL**

## Westinghouse induction heating doubles axle



1. A single operator surface-hardens 6 rear-axle shafts at each setup of this Westinghouse induction unit. Production per hour totals 210 shafts.

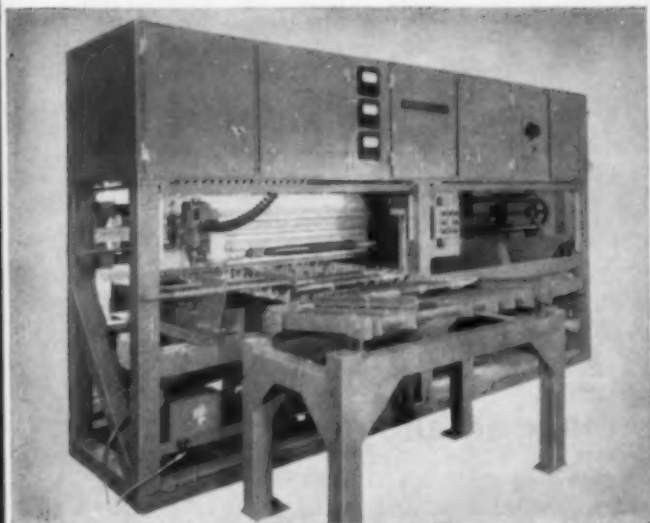


R. C. Cheek  
*Manager, Induction  
Heating Department*

"Three different axle-hardening applications," reports R. C. Cheek, "show a slice of Westinghouse experience in solving production line heat-treating problems. Dependability of Westinghouse induction equipment, for example, protects production timing and holds maintenance to a minimum. Results are measured, too, in three important profit advantages."

1. Twice the axle fatigue life is obtained from lower cost, plain carbon steels. No more need for costlier alloys.
2. Lower carbon steels lengthen tool life . . . reduce machining and replacement costs.
3. Axle shaft distortion is minimized by rapid induction heating and quenching.

## fatigue strength . . . lowers cost



2. Up to 33 axle shafts per hour, 42 inches long and weighing up to 100 lbs., are surface-hardened by this Westinghouse induction equipment.



3. Westinghouse general-purpose induction scanner handles shafts up to 30 inches long, 80 lbs. weight, for surface-hardening and quenching.

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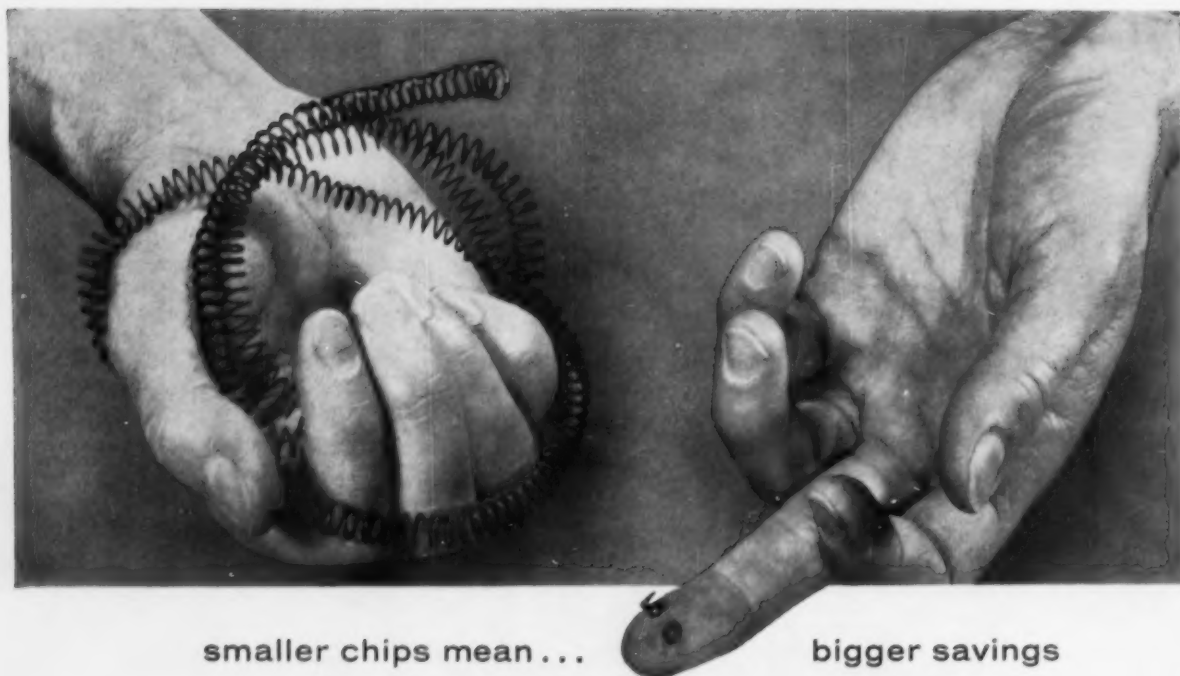
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# Metal Progress

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## Ferrosilicon Manufacture at Marietta

By E. E. THUM\*

Ferrosilicon is only one of many electric furnace products made at the Marietta Works of Electro Metallurgical Co., a Division of Union Carbide and Carbon Corp. Equipment and operations are quite different from those in conventional iron and steel works, as the following detailed description will indicate. (C 21, Si, Fe-n)

AN ELECTRIC FURNACE for smelting silicon is a curious piece of equipment — at least to one who has roamed around the iron and steel industry for a lifetime. It is a big squat pot with three large vertical carbon electrodes; quartz and coke are piled up around the electrodes; flames play quietly on top the charge; 15 times a day about 2 tons of metal are tapped from the bottom. No blast, no oxygen, no sputter, no roar. Just as easy as that!

The operation is curious in other ways: Carbon and silicon are next-door neighbors in the

periodic sequence and so are quite similar chemically; they have the same number of electrons in the two outer shells. Furthermore, the heat of formation of  $\text{SiO}_2$  at 3000° F. is at least twice as large as that of CO — so you would not expect carbon to be able to take oxygen away from silica. Finally, the charge goes into the furnace as walnut-sized pieces of rock and coke; how can there be enough *physical* contact between these two materials for reaction to occur at a measurable rate? (Remember that in the iron blast fur-

\*Editor, *Metal Progress*, Cleveland.

nance the reaction is between solid iron oxide and gaseous carbon monoxide; in the electric steel furnace the reactions are between liquid metal and liquid slag; in both of these mixture can be intimate, chances of reaction are infinite.)

Nevertheless this simple submerged arc furnace, as it is called, is a smoothly acting machine. The doubts just expressed must be based on some false assumptions. Now that one thinks about it a little he will remember that pig iron from an ordinary blast furnace contains up to 3% silicon,

and this must have been reduced from silicates in the ore or coke ash at temperatures much lower than exist momentarily and locally in an electric arc. He also knows that the hotter the blast furnace is running the higher the silicon in the iron; presumably at the exceedingly high temperature of the arc, carbon has a higher affinity for oxygen than silicon has.

But before going on with these speculations it would be well to describe the furnace and its associated facilities as they exist in the model

*Fig. 1 — Stock House With Skip Ways Leading up to Peak of Furnace Buildings at Marietta Works of Electro Metallurgical Co., a Division of Union Carbide and Carbon Corp. Photo taken before the mix house was extended and the third skip hoist installed in the distance*





*Fig. 2 — Ladling Ferrosilicon Through Graphite Pouring Basin Into Pans, Made of Cast Iron and Washed With Mixture of Graphite and Silica*

plant of Electro Metallurgical Co. at Marietta, in southern Ohio.

#### **Plant Arrangement**

**The Cold End** — Most raw materials are delivered to Marietta by railroad, and are stored in piles, lot by lot, or cargo by cargo, in an open yard. During unloading the lot is sampled for chemical analysis. Silicon furnaces consume quartz gravel or crushed quartzite; carbon is from coke, low-volatile coal, and wood chips. Iron for ferrosilicon is short steel turnings, mill scale or iron sinter — all relatively cheap and pure sources of metal. The quartz should be as high in grade and the carbon as low in ash as possible to reduce the slag volume to the vanishing point; furthermore some customers want a low-aluminum

product and the easiest way to make this is to keep alumina out of the charge by selecting the proper quartzite, gravels, and reducing agents. (If a particularly higher aluminum ferro is specified, a small amount of shot aluminum can be added to the ladle.)

Locomotive cranes with grab buckets, helped by small bulldozers, load raw materials into hopper-bottomed cars which are pushed up to the top level of the mix house, on schedule to keep the bins full of correct raw materials. This mix house, shown at the right of Fig. 1, serves the three furnace buildings at Marietta with their 14 furnaces making many different alloys; it is a quarter of a mile long, one bin smack up against another. Unloading 1500 tons of material per day from railroad cars to bins requires only three men

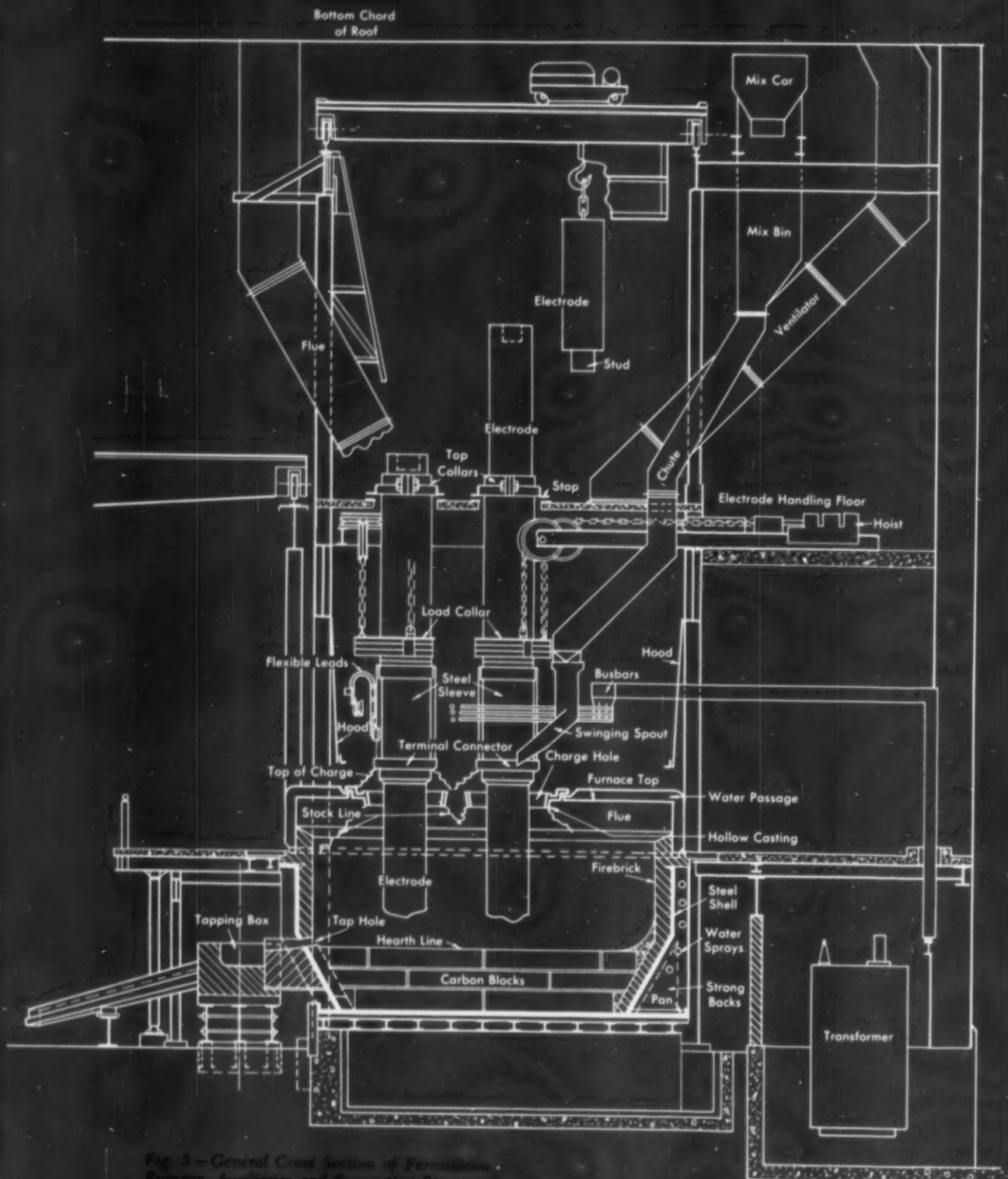


Fig. 3 - General Cross Section of Ferroalloy Furnace, Auxiliaries and Supporting Structure

per shift, thanks to a very efficient and noisy vibrator which is lowered on the car and shakes the living daylight out of it.

On the ground level five weigh-cars shuttle back and forth, stopping at proper bins to draw out the correct amount from each in succession to assemble a correct mix for each furnace. Here also there is a small vibrator at each spout and the car-man, by remote control, can draw off the weight given him on his instruction sheet to an accuracy of 5 lb. These weigh-cars have two hoppers; two identical charges are made up; the car then runs down to a skip pit, and both charges dump simultaneously. The loaded skip then is pulled up an incline to dump in a transfer car running along a track up under the roof of the furnace building to the proper bin (as selected by the far-distant weigh-car operator). An automatic tripper drops the load into bins, which serve the furnace below through long chutes ending in swinging spouts near each electrode. Feed is spread over the furnace top as the operator wishes; he merely moves a lever to release the mix and another to swing the spout.

Here we have a good example of automation. Not counting the men in the stock yard or the switching crew, there are three men on top of the stock bins, five men at the weigh cars, and two men on the trainway above the furnaces — ten men per shift or 30 men per day handling 1500 tons of charge material — 12,500 lb. per man-hr.

**The Hot End** — Now let us assume that the furnace is ready to tap. The workmen, standing on a ramp built up on the ground floor, open the tap hole by picking out a 5-in. carbon ball with a long sharp steel rod. The molten alloy flushes rapidly from the furnace into a ladle at the furnace lip.

When the flow slows down to a trickle, the tap hole is stopped by forcing a new carbon ball into the hole; it is stuck on a small mushroom head on the end of a long steel rod. The tap hole tends to close in, so it is part of the workman's job to maintain a 5-in. tap hole either with an electric arc burner, occasionally driving a fair sized sapling into the hole, or working the open hole with long steel rods. If the lining gets too thin at the breast it may be built up from the outside by ramming carbon paste or other appropriate refractory.

Ferrosilicon may be run directly into pans on the ground floor, as is indicated in the painting

from which the cover of this issue of *Metal Progress* has been copied. However, normal practice is for the liquid to be caught in a ladle (meanwhile additions of aluminum are made if desirable), and then lip-poured into cast iron pans or flat molds, as shown in Fig. 2. (The tapping box dish shown in the line drawing, Fig. 3, is cut from an electrode stub.) Molds are washed with a mixture of graphite flour and silica dust, to avoid rapid scour.

Solidified cakes are dumped into a heavy-floored, sloping bin with staked front. Workmen sledge the brittle metal, separating the little slag and any loose clay coming from runners or ladle, and the large chunks are fed into an extensive crushing and screening system — practically automatic — to prepare sizes according to customers' specifications.

### Electrode Manipulation

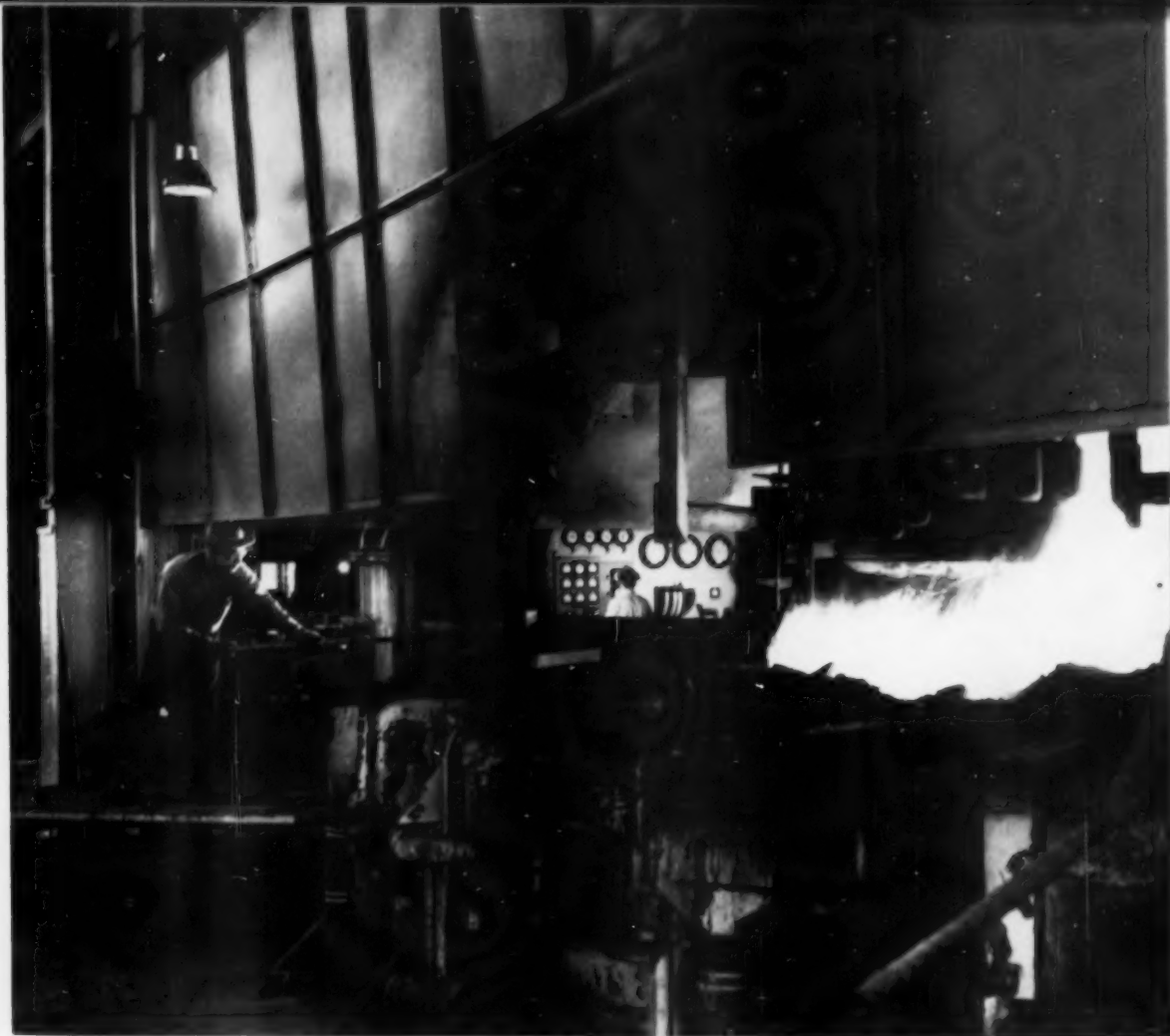
As shown in the sectional drawing, Fig. 3, the carbon electrodes are very large, being 35 in. diameter and in 9 ft. 2 in. lengths. The electrode handling floor requires about 24 ft. of head room under the 5-ton traveling crane. When an electrode has been consumed so its top nears the handling floor (the left electrode in the drawing), current is shut off long enough for a new section to be screwed into place, the joint being first covered with a special joint compound.

Electrodes and fittings are heavy enough so gravity is a positive downward feed. Position is therefore controlled by hydraulic rams or hoists — one for each of the three electrodes — set horizontally on the electrode handling floor at appropriate angles. Three chains run from the cross-head of each ram over sheaves to attach at third points to a load collar which is the device for suspending the entire electrode holder.

The electrode holder consists of a cylindrical shell extending from the terminal connectors to the electrode handling floor. The electrode column, consisting of several lengths of carbon, is free floating inside the holder, being held by two split rings. The lower ring is located at the terminal connectors and the upper split ring rests on the top of the electrode holder. To bring out additional electrode below the terminal connectors the electrode column is settled against the charge in the furnace, bolts in the upper and lower split rings loosened, and the electrode holder raised by the hydraulic hoist. Both split rings are then retightened. (This description can be clarified by the drawing, Fig. 3.)

The section of the cylindrical shell of the

Fig. 3 — General Cross Section of Ferrosilicon Furnace, Auxiliaries and Supporting Structure



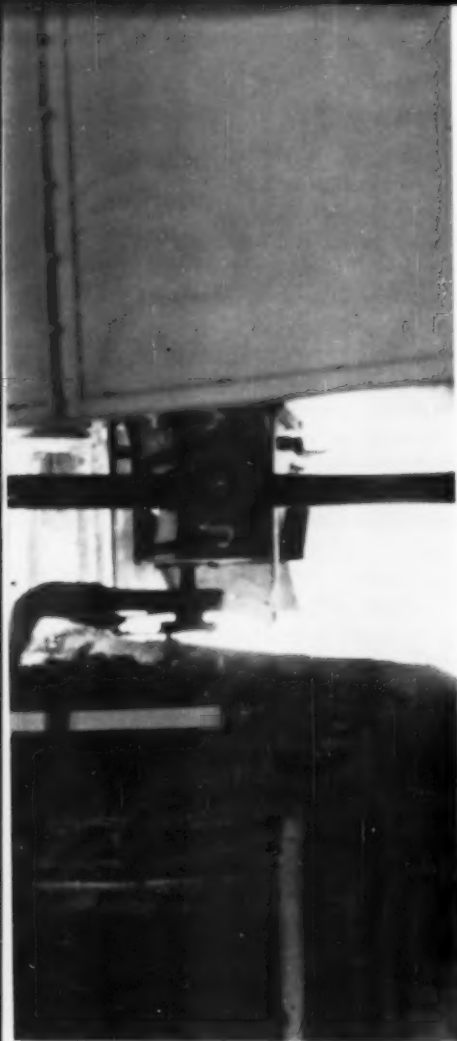
*Fig. 4 — Top of a Ferrosilicon Furnace in Action. The workman at left is pushing loose charge to a place where hot gases are blowing up near one electrode. In the background the head furnace-man is checking the controls. The lever in right foreground moves the swinging charge spout — although this is usually done by remote control. Water-cooled working doors are fitted into the vertical wall of the furnace top*

electrode holder between the load collar and terminal connector is a water-cooled sleeve whose inside clears the electrode by about half an inch. An air line keeps this annular space under slight pressure, preventing infiltration of dust which might cause short circuits. Connections between the busbars and water-cooled terminal connector are by several flexible leads (copper cables, water cooled) so designed and of such number as to produce uniform current density in the electrode and minimize electrical resistance and impedance.

Current is supplied at 60 cycles from Electro Metallurgical Co.'s own 160,000-kw. steam generating station nearby. Transformers, close up, change the line voltage of 13,800 to 160 to 200 volts for the furnace. Electrode spacing of 8 ft. on centers and a mix of correct conductivity will

pass a current of 42,000 amp. in each phase. Voltage is changed by changing the transformer tap, and is adjusted for the type of alloy being produced. The furnace man keeps the amperage going into each electrode at a steady rate; short-time adjustments are by raising and lowering an electrode; longer-time adjustments are by changing the coke size and the "porosity" of the mix, as will be described later. Power consumption varies from about 7.0 kw-hr. per lb. of silicon when making silicon metal, to 5.0 kw-hr. per lb. of silicon when making 50% ferrosilicon.

Although the electrodes in the drawing are shown a couple of feet from the carbon hearth, it is quite likely that a large portion of the current passes from electrode to electrode through the charge or mix, rather than from electrode to hearth and then back to another electrode. In



fact, resistance of the charge (and, inversely, the amount of current) depends upon the average size of coke in it — the coarser the coke the more the current and the hotter the furnace. Taking advantage of this fact, a cold furnace is started up on a thick layer of coarse coke.

#### Furnace Construction and Operation

Essential details of the furnace are shown in the sectional drawing, Fig. 3, and a photograph of the top, in action, in Fig. 4. Its lower shell is a large steel pot 26 ft. diameter and 10 ft. deep, with tapered bottom corner. It rests on a beam grillage and is held to shape by 24 strongbacks equally spaced around the circle. This shell is lined with 17 in. of ordinary firebrick; the lining extends up and outwardly over the top edge of the shell to form an insulating shelf for the fur-

nace top. The flat hearth consists of three layers of 16-in. carbon blocks. Water sprays may be played on any hot spot on the shell, although this expedient is very seldom necessary. A small bank of magnesite protects the junction of brick wall and carbon hearth.

The furnace top is like an inverted bowl which rests solidly on this base. Looking down from above, it appears to be made in three 120° pie-shaped segments, separated (electrically insulated) each from each by a course of firebricks, T-shaped in cross section. Vertical sides and flat top are made of ¾-in. steel plates separated 2 in. for water circulation. Numerous doors are let into the vertical sides, through which any crusts forming on the top slope or "lid" of the stock can be broken up, either by manpower or by air-operated punchers. At one place, also, is a 2-ft. square opening leading to a chimney, through which most of the gases are led off to water sprays and scrubber. This gas is almost pure carbon monoxide, and can be used for its fuel value. Gases which seep up around the electrodes burn as soon as they reach the air, and smoke and dust are caught in a generous hood and drawn off to a chimney.

These three steel segments forming the furnace top are so shaped on their inner edges that a large circular opening remains, 15 ft. in diameter. This in turn is filled by three water cooled sections made of Everdur, a non-magnetic, austenitic alloy. Each of these segments has a circular opening for an electrode, with lips so shaped as to form a 12-in. annular chute. All the smelting mixture entering the furnace goes through these holes.

So much for the furnace construction. It is really better described by Fig. 3, the general cross sectional drawing, than by words. Now for a few generalities about its operation.

**Operation** — As mentioned at the very outset, carbon (coke) and silica (quartzite) are charged in stoichiometric ratio for the reaction  $2C + SiO_2 = Si + 2CO$ , electric power is led in through the electrodes, nearly pure carbon monoxide gas is drawn off the top, and periodically molten silicon is tapped from the bottom. In fact the carbon balance is rather critical; it can't be deficient for reasons later to be developed; if there is an excess, silicon carbide is formed which is not only refractory but quite conductive.

The technical mind seeks similarities between the above and the running of the conventional iron blast furnace. Obviously there are funda-

mental differences, because in the latter the source of heat is the combustion of excess coke in the charge by a blast of hot air blown through tuyeres a few feet above the hearth. Other much more subtle differences exist.

When an iron blast furnace is drained, cooled, and opened for repairs, the partly smelted mixture in the upper part of the shaft is resting on a honeycomb of coke which entirely fills the hearth. When the furnace is in operation, drops of reduced metal and superheated slag have trickled down through this honeycomb and collected in a liquid pool at the very bottom.

Now a silicon furnace is short; metal (silicon) is not reduced by carbon monoxide as it is in the shaft of the tall blast furnace. Hence it is that when an electric furnace of this sort is shut down for repairs, the cold hearth contains an almost solid mass of coke particles, silicon carbide, and once-fused silica.

This last fact gives some clue to the mechanism of the reduction. When the silica and coke enter the furnace as small pieces they touch only at points, and can react only at such contacts. However, the charge does not need to settle very far in the furnace until the silica starts to act like plastic hot glass (it devitrifies at 2000° F. and melts at 3175°). Approaching the focus of the furnace there probably is an oozing mass of nearly fluid silica engulfing the coke. This gives good contact between the reacting substances, and the pasty fluid is stirred sluggishly by the bubbles of CO gas as they escape.

Metallurgists at Marietta believe that at no time is there a large pool of liquid metal (silicon) on the hearth as would be found in a furnace producing metal *plus* a considerable amount of slag — rather that a kind of porosity is maintained in this silica-coke mass which may be visualized as a complex interlacement of open passages, not permanent but continually pinching out and re-opening elsewhere, always interconnected and holding either molten silicon or carbon monoxide gas. When the furnace is tapped the silicon drains out (never completely). Silicon itself melts at 2600° F., and the ferrosilicons somewhat lower. Steady operation requires a charge which will maintain these conditions, literally in a state of flux.

The operator calls it a proper state of "porosity". Deficient porosity in the silicon furnace is corrected by altering the size of the materials and the type of reducing agents in the charge. The needed "porosity" in the reacting mix may

be ascribed to the physical state and electrical properties of the remaining carbon sponge. Likewise "porosity" is much better in a furnace making ferrosilicon, wherein the spongy steel turnings in the mix furnish fusible particles of high electrical conductivity.

At any rate the physico-chemical conditions at small regions of intense heat, where the current arcs across a gap from one conducting particle to another, are such that the activity of carbon is very great. One would expect that iron rust on the steel turnings would be reduced readily. One would not expect, however, to find so much aluminum in the resulting alloy. (A larger proportion of the aluminates entering the furnace as impurities in the quartz or ash in the coke is reduced in the silicon metal than when the furnace runs somewhat cooler and is making ferrosilicon.)

Carbon is practically insoluble in ferrosilicon and silicon; so there is no wash on the carbon hearth. Carbon blocks thus make an almost ideal bottom. It requires no high degree of skill to lay the blocks and mortar them with carbon paste; they are not dissolved by the hot product; they have good conductivity for heat. (A very considerable amount of heat must escape by radiation; unless it could be taken away efficiently, you can imagine what would happen to the firebrick side walls.)

Accumulation of reduced metal in the furnace is estimated by the integrated electrical output. For example, a furnace making silicon can tap about 1700 lb. when 10,000 to 12,000 kw-hr. of power has been consumed. A 50% ferrosilicon furnace produces about twice as much; when 16,000 kw-hr. of power has been consumed about 3.25 tons of metal can be tapped. A furnace crew of 5 men thus is responsible for about 16 tons of product per shift.

### Conclusion

While Electro Met's furnaces at Marietta have every appearance of docility, they obviously have been tamed through many years of hard experience. No attempt can be made in such a short account as this to sketch this essential historical development, nor to discuss any of the emergencies which may even yet unexpectedly develop without much if any warning. The most that can be said is that this plant could well be a model for those who, filled with the spirit of automation, desire to relieve human beings from a great load of hot, dusty, heavy labor. ☐

# A New Composition for Fast Malleable

By A. L. BOEGEHOLD\*

A pinch of tellurium has been used in high-silicon malleable to produce a white iron even in large sections. 0.025% Bi plus 0.003% B does the same thing and eliminates objectionable "foundrymen's halitosis". (E 25, B 22, CI)

**I**N AN ADDRESS entitled "Materials in the Automobile of the Future", presented in April 1956 before the Cleveland District of the American Society for Testing Materials, I spoke of the competition between castings and forgings which has already resulted in the equipment of about one-quarter of the cars now being made with cast crankshafts. I also expressed the opinion that the combination of shell molding and fast malleable analyses and processes would present economies which would be rather compelling to the cost-conscious automobile manufacturers. This article will expand this thought by describing rather briefly the new Pontiac crankshaft, being made at the rate of 2600 daily at the Dan-

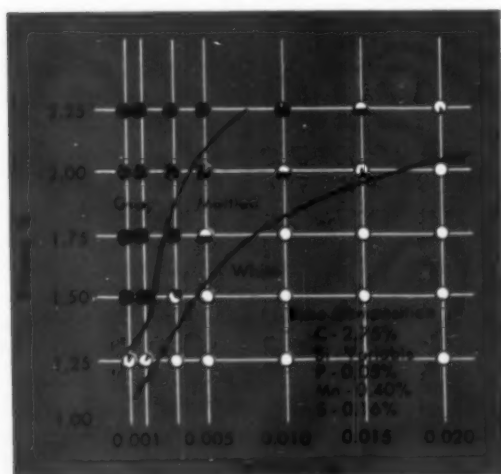
ville plant of Central Foundry Div. of General Motors. The success of this crankshaft depends on a new alloy developed and patented by General Motors research staff.

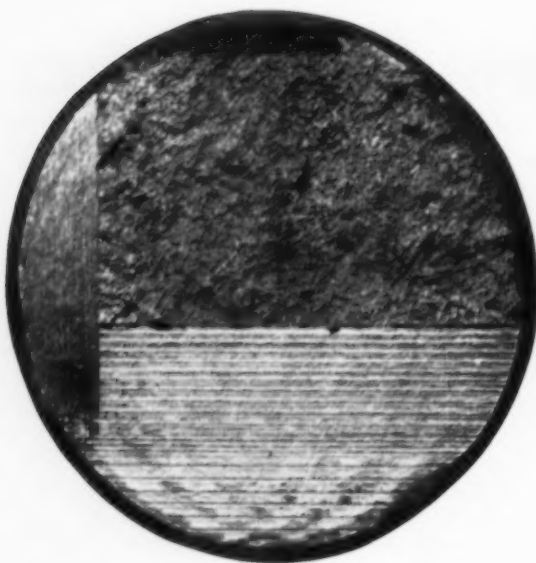
The usual form of pearlitic malleable iron is unsuitable for section sizes much greater than  $\frac{1}{2}$  in. thick. A round section  $1\frac{1}{2}$  in. in diameter is about the limit that can be cast free from mottle. However, by the addition of 0.025% bismuth and 0.003% boron, a section up to 5 in. in diameter can be cast without mottle. This characteristic makes such an iron suitable for crankshafts or other heavy-section castings. The accompanying photographs show the extent of mottling in the fracture of regular malleable compared to the bismuth-boron malleable. The small section is  $1\frac{1}{2}$  in. in diameter which is about equal to the middle of the sprue regularly cast to control quality in production. The larger sections are 2 $\frac{1}{2}$  in. in diameter, about three times the cross-sectional area of the smaller. Compare the fracture of the regular iron with that of the bismuth-boron. It is amazing that this powerful carbide-controlling effect is accomplished with two parts of bismuth in 10,000 parts of iron!

It is an interesting fact that the objective of the original development was to produce a faster-annealing malleable iron. The idea was to raise the silicon content to speed up the carbide decomposition and then to introduce a carbide stabilizer which would counteract the graphite-forming action of the increased silicon during solidification, but which would not interfere with carbide decomposition during annealing. Tellurium turned out to be such a stabilizer.

\*Manager of Research Staff Activities, General Motors Corp., Detroit. Past President.

*Mutual Effects of Tellurium and Silicon on Fracture (and Capability for Rapid Malleableizing) of 2-In. Rounds, Sand Cast*





*Regular Pearlitic Malleable, 2.75-In. Diameter*



*Regular Pearlitic Malleable, Bismuth Inoculated, 2.75-In. Diameter*



*Regular Pearlitic Malleable, 1.75-In. Diameter*

Tellurium was later replaced by bismuth, which was found to act the same as tellurium without having the objectionable property of rendering those who breathed the vapors socially unacceptable. It induced pronounced halitosis with a garlic cast! Also, the use of bismuth gives more uniform results. Tellurium-treated malleable iron was put into the pistons of early diesel locomotives, replacing the original aluminum pistons because of greater durability.

It was during the manufacture of these large pistons — 10 in. in diameter — that it was found that castings of larger section size could be made with the aid of tellurium. These castings, made from regular malleable iron, would have required a drastic reduction in silicon content to avoid mottle, with the result that annealing time would

have been greatly increased. By adding tellurium and increasing silicon somewhat, the larger castings were annealed in the same cycle used for the standard run of smaller castings — which at that time was around 36 hr.

The graph shows how tellurium affects the structure. Here we see that with 1 $\frac{3}{4}$ % silicon and no tellurium, a casting of 2 in. diameter would have a structure as-cast suitable for converting into malleable iron. But with 1 $\frac{3}{4}$ % silicon and no tellurium, the structure as-cast would be entirely gray, and such an iron would of course be unsuitable for making into malleable iron. But with this silicon content the addition of 0.005% tellurium would cause the structure to be free from flake graphite — that is, all the carbon would be combined, causing a white fracture, and this would be suitable for converting into malleable iron by annealing. Furthermore, because of the higher silicon content, annealing would be considerably more rapid, and because of the tellurium present, such iron would be useful for making malleable iron in sections heavier than 2 in. in diameter.

A final and most important consideration is that shell molding enables us to cast the crank cheeks sufficiently accurately that machining is unnecessary. Another saving results from the fact that machinability of the pearlitic malleable is much better than that of steel.

These crankshafts have proved satisfactory in every respect, both from the engineering and cost standpoints.



*The Aluminum Curtain Walls of the Alcoa Building Are Anodized for Permanent Beauty*

# Finishes for Aluminum Alloys

## Part I—Electrolytic or Anodic Coatings

*By* WALTER E. POCOCK\*

Anodizing increases the corrosion resistance and improves the appearance of aluminum alloys. The various processes and the properties of the resultant coatings are described. (L 19, Al)

**V**ARIOUS ELECTROLYTIC and chemical treatments are used on aluminum alloys to improve their natural corrosion resistance, provide a base for organic finishes or produce decorative surfaces. Electrolytic oxidation, or anodizing, was once used almost exclusively; now, low-cost chemical treatments have replaced anodizing in many applications.

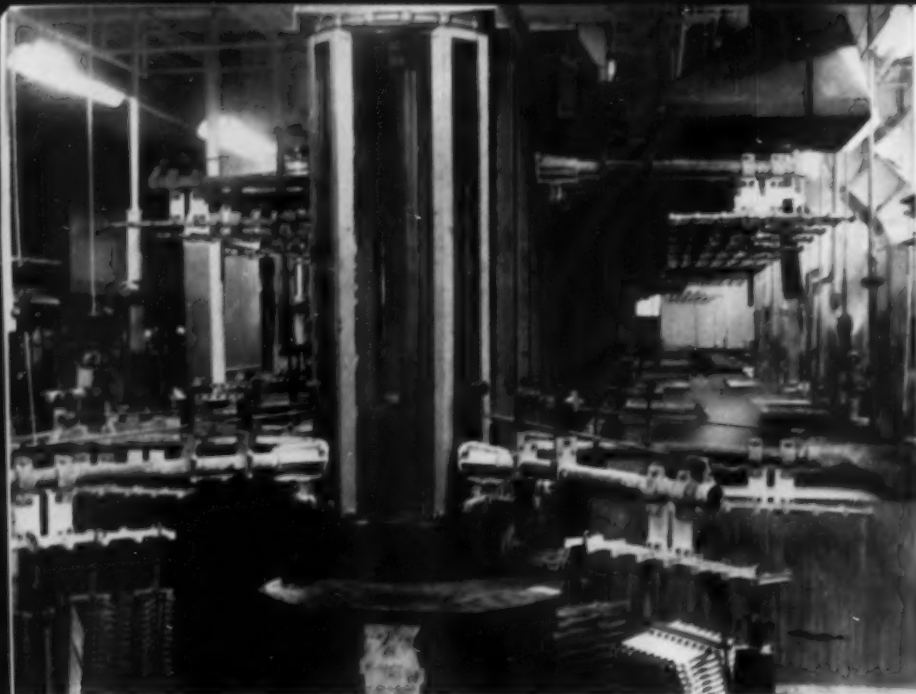
The two kinds of coatings are not identical although they can often be used interchangeably. The anodized coatings are harder, more resistant to abrasion and are used as a base for highly decorative finishes. Chemical coatings are much less expensive to apply, more flexible and inhibit corrosion even when the surface is scratched.

There are a number of different solutions for each of the two kinds of treatments, and selection of the proper process requires a complete engineering evaluation of the service conditions.

Before either electrolytic or chemical finishing, the surface of the aluminum must be cleaned properly. All oils, grease and soil must be removed completely. For chemical finishing, the oxide film present on aluminum must first be removed. Deoxidation is not used as often prior to anodizing but it does improve uniformity and protective value of the final coating.

Alkali etching does a particularly thorough

\*Development Engineer, Allied Research Products, Inc., Baltimore, Md.



*Automatic Anodizing Machine for Aluminum Refrigerator Parts. (Courtesy Hanson - Van Winkle - Munning)*

cleaning job, since a perceptible amount of metal is removed. Etching is also used to produce a decorative frosted finish. Where paint is to be applied, etching improves the initial paint bond.

An alkaline solution which does not etch is used where vigorous attack of the metal is objectionable. The oxide film remains after the alkaline cleaning step. Various acid mixtures, such as chromic-sulphuric and chromic-phosphoric, have been used for oxide removal but the proprietary chromate deoxidizers are especially effective.

Electrolytic oxidation is carried out by making the work the anode in an electrolytic system — hence the term anodizing. Oxygen from either the water or the electrolyte in the bath reacts with aluminum under the influence of the applied voltage and forms a coating of amorphous aluminum oxide. Hydrogen is evolved on the cathode surface. The problems of current distribution and covering power encountered in electroplating are practically nonexistent in anodizing because the greater part of the electrical resistance of the circuit is in the coating itself rather than in the electrolyte as in electroplating.

By proper control of operating conditions, a very hard protective coating is produced which can be modified in appearance and physical properties by post treatment in dye solutions and sealants. Chromic, sulphuric, oxalic, boric, sulphamic, phosphoric and mixed sulphuric-oxalic acids have all been used as electrolytes. Only the first two are in wide commercial use, however, and our discussion will be limited to these.

The sulphuric acid process is applicable to all alloys of aluminum and has been particularly successful for decorative work. The material is cleaned thoroughly, rinsed and then anodized in a 15 to 25% sulphuric acid solution at 65 to 80° F. for 15 to 60 min. The current density is between 10 and 25 amp. per sq. ft. and the voltage is 12 to 18 v. The anodized part is rinsed in cold water and then sealed by immersion in hot water (208 to 212° F.) for 10 to 20 min.

The anodic coating as formed has microscopic pores. Immersion in hot water causes hydration of the anhydrous oxide to the monohydrate,  $Al_2O_3 \cdot H_2O$ . The accompanying swelling seals the pores, increasing the corrosion resistance of the coating and making it resistant to further absorption. The addition of 5% sodium or potassium dichromate to the sealing water increases corrosion resistance still more.

Many organic dyes are readily absorbed by the porous oxide film. If the latter is fairly clear in color as on alloy 1100, 3003 or 5052, attractive bright shades of red, yellow, blue, green, violet and gold can be obtained. Success in dyeing depends on careful control of anodizing conditions. After anodizing, the part is immersed in the dye solution at 140 to 160° F. for 5 to 15 min., rinsed in cold water and sealed in a nickel acetate solution.

The light-fastness of dyed coatings depends to some extent on the amount of dye absorbed but much more on the dyestuff itself. These dyed finishes cannot usually be recommended for outdoor use, although recently a series of anodizing

dyes of reportedly exceptional light-fastness have appeared on the market.

The anodizing tank is lined with lead and the lining is the cathode in the process. An acid resistant plastic lining may be used with lead cathode bars suspended in the bath. The tank must have a cooling coil to remove heat generated in processing, and the bath should be agitated to insure uniformity of temperature. Exhaust ducts over the anodizing tank are recommended for exhausting hydrogen and electrolyte spray.

For the dye and nickel acetate solutions, stainless steel and Monel are the preferred tank materials. Plastic linings may be acceptable for dye solutions if they withstand temperatures of 140 to 160° F.

Racks are of aluminum, preferably plastic-coated except in the contact areas. Sufficient pressure must be maintained between the work and the supporting rack members to insure good contact. Small parts may be processed in bulk in perforated aluminum cylinders on which the head can be tightened to give the necessary contact pressure with the work.

Physical properties of the coating depend to a great extent on alloy composition. Coatings on alloys which are not heat treated are the hardest and clearest in color. As the percentage of alloying constituents increases, the coating becomes less abrasion resistant, less corrosion resistant and darker in color.

Corrosion resistance for a given alloy and given process conditions is approximately proportional to coating thickness, and is increased by hot water or dichromate sealing. Military specification MIL-A-8625 A requires that the anodic coating produced on a test panel of 2024-T show no more than slight corrosion after exposure for 240 hr. in a standard 20% salt spray test; or that any corrosion occurring cause not more than 10% reduction in elongation or 5% reduction in tensile strength in a standard tensile test. A 20 to 30-min. coating, dichromate-sealed, will usually meet this requirement without difficulty. A dyed coating would have to be somewhat heavier for equivalent results.

Anodic aluminum oxide has been compared in hardness to razor steel, chromium and sapphire. This property, like all others, varies with the alloy and process conditions. Since the coating is quite thin, resistance to abrasion depends on thickness as well as hardness. The coating is brittle and tends to flake off the surface when subjected to sharp bending.

The degree of electrical insulation, or dielectric

strength, is proportional to coating thickness and is increased by sealing. Breakdown voltages have been reported in the range of 100 to 200 v. per 0.0001 in. of coating and one-third to one-half of these values where weak spots occur.

The sulphuric acid process is used largely for decorative purposes. Applications range from knitting needles and jewelry to exteriors of buildings. Perhaps the most familiar examples are kitchen articles, such as drinking tumblers, pitchers, trays and aluminum refrigerator parts. Undyed coatings find extensive use in exterior building trim, doors and window frames. For interior work, such as railings and doorknobs, the oxide coating provides resistance to smudging and perspiration staining.

Lettering or other desired patterns can be reproduced on such articles as instrument panels, name plates and camera parts, in two or more colors. A "resist" is used which permits dyeing of the anodized surface in parts or complete dyeing, then partial removal of the dye.

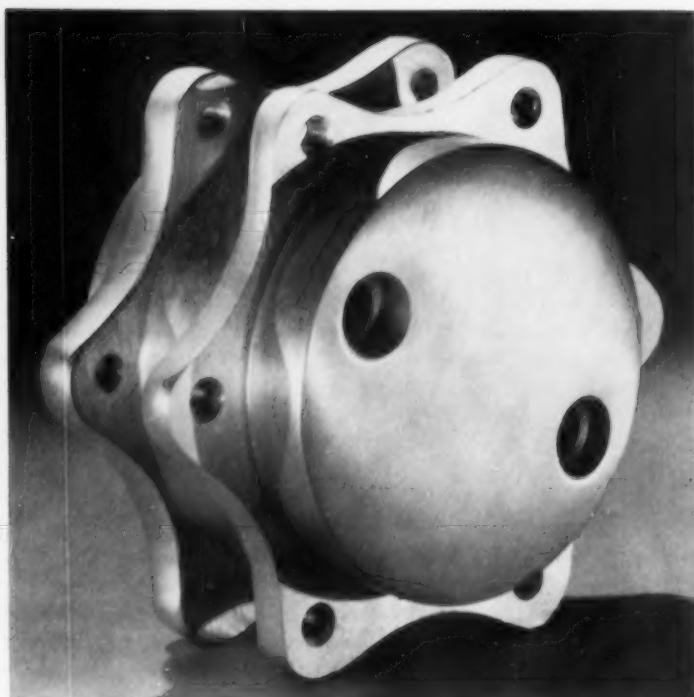
The chromic acid process was the first practical anodizing procedure to be developed. Its present use is for articles with crevices or lap joints where electrolyte is entrapped and not removed in the rinse step. The sulphuric acid electrolyte in such parts can cause corrosion, whereas entrapped chromic acid has a neutral or corrosion inhibiting effect. Although the process is limited to alloys containing not more than 5% copper, this is not an extremely serious drawback since most wrought alloys and many cast alloys are within this limitation.

The electrolyte is a 5 to 10% solution of chromic acid held at 90 to 100° F. for undyed coatings and 120 to 125° F. for coatings which are to be dyed. The current density is 1 to 3 amp. per sq. ft. and the voltage is 40 v. Anodizing time is 35 to 65 min., depending upon the thickness of coating required.

Hot water or dichromate sealing is advisable where the coating is to be used as a final finish but this is not as essential as with the sulphuric acid process, except following dyeing. Chromic acid retained in the coating during anodizing contributes to its corrosion resistance, its effect being similar to that of sodium or potassium dichromate in dichromate-sealed sulphuric acid anodic films.

The procedure for dyed finishes is about the same as with the sulphuric acid process. The dyed coatings tend to be dull and opaque and are not generally used for decorative purposes.

The anodizing bath is controlled by specific



*Aluminum Bottling Machine Component Indicates the Complexity of Shape That May Be Anodized Successfully*

gravity and pH measurement. Chromic acid additions are made periodically to replenish processing losses and maintain the desired pH value. As the solution is used, it gradually becomes buffered by dissolved aluminum and trivalent chromium, and eventually a part or all of it must be discarded and replaced with fresh chromic acid. In recent years, it has become commercially feasible to reclaim spent chromic acid baths by removing aluminum and trivalent chromium with ion-exchange resins.

Equipment is similar to that for sulphuric acid anodizing, with these exceptions:


1. Tanks, heating coils and air lines for agitation can be of steel which is not attacked by the chromic acid electrolyte.
2. The required cooling capacity is less than for the sulphuric acid process and provision for heating is usually necessary.
3. The power requirement for a given amount of surface is less than with the sulphuric acid process.

Chromic acid anodic films are quite similar to the sulphuric coatings since both are essentially amorphous aluminum oxide. The coating compositions differ somewhat because of the different electrolytes used. Chromic acid coatings are darker in color and more opaque and in

general are softer than those obtained in the sulphuric acid process. The chromic films are thinner, ranging from about 0.00002 to 0.0002 in. in commercial practice.

The chromic acid process is preferred where entrapment of electrolyte can occur. It has long been used, for example, in the aircraft industry for this reason. It is also used in some instances as a paint base but has been replaced to a large extent in such applications by chemical coatings. Dyed chromic acid anodic films are applicable where nondecorative color is desired or where the sulphuric process is prohibited because of electrolyte entrapment. Another use is for detecting stress-produced cracks in aluminum parts, the method depending on the absorption of chromic acid in the cracks during anodizing.

A third anodizing process that deserves mention is that developed by the Glenn L. Martin Co. An electrolyte of 15% sulphuric acid saturated with carbon dioxide is used at very low temperatures. Exceptionally hard coatings, up to 0.005 in. thick, can be produced. They have been used successfully where an unusual degree of abrasion resistance is needed.

The various kinds of chemical treatments and their properties and applications will be described in a subsequent article. 

# Limitations to Processes Using a Metal as a Reducing Agent

By L. M. PIDGEON\*

While magnesium and calcium are very useful reagents for reducing some of the "new" or reactive metals from purified chemical compounds, certain limitations are fixed by their chemical and physical properties—notably, the free energy of formation of their slag reaction products, their melting and boiling points, and their tendency to alloy with the desired metal as it is produced. (C 26, T 5, Mg, Ca)

AN ARTICLE entitled "The Reduction of Ore to Metal" in the August issue of *Metal Progress* contained a simplified statement of the four methods which have been commercially used—two since ancient times—for the production of metal, that is, its separation from a natural mineral or chemical compound. Some of the advantages of each method were given, as well as the limitations both theoretical and practical.

The fourth of these general methods, namely, the displacement of one metal from its chemical compound by another is indicated by the typical reaction



where M is the metal we want to produce, y is some nonmetallic element or radical with which

it is in combination, and x is another metal used as a "reducing" agent. As was pointed out in the article in August, this scheme was used long before it was understood, dating back at least to the Roman workings of the Rio Tinto copper mines in Spain. It has suddenly come into prime importance as a means of producing many of the "reactive" metals required for supersonic aircraft and atomic power reactors. For that reason we will now describe—again in simplified and somewhat generalized terms—the physical and chemical properties of the reactants My and x and the products xy and M.

The reactions should be exothermic and self-

\*Professor of Metallurgical Engineering, University of Toronto.

**Table I—Free Energy of Formation of Oxides  
(per Oxygen Atom)**  
(J. P. Coughlin, U.S. Bureau of Mines Bulletin No. 542)

At 227° C.	At 727° C.	At 1227° C.	At 1727° C.
Ag +0.06	Cu -23.3	Cd -14.4	Na -7.9
Hg -8.8	Pb -28.7	Cu -15.2	Cu -10.7
Cu -31.5	Ni -35.0	Pb -18.7	Ni -13.0
C(O) -37.1	Co -38.8	Ni -24.2	Zn -15.0
Pb -40.4	Cd -37.7	Co -29.5	Co -19.9
Ni -46.1	Fe -47.8	Na -38.6	Fe -33.8
Co -47.9	C -47.9	Zn -38.9	Cr -49.1
Cd -50.4	Zn -61.4	Fe -40.0	Mn -55.1
Fe -55.5	Na -65.5	C -58.3	U -59.6
Zn -71.3	Cr -69.7	Cr -59.5	V -60.5
Cr -81.6	Mn -74.5	Mn -65.6	Si -61.9
Na -83.0	V -79.0	V -69.5	C -68.5
Mn -83.1	Si -83.4	Si -73.1	Ti -70.1
V -89.0	Ti -91.1	Ti -80.5	Mg -76.1
Si* -94.0	U -109.0	Li -92.0	Al -82.0
Ti† -101.2	Al -108.2	Al -95.1	Ba -86.0
U‡ -119.1	Ba -110.5	U -98.8	Ca -95.5
Al -120.7	Li -110.2	Ba -99.0	Be -96.6
Ba -121.5	Mg -117.7	Mg -101.3	
Li -127.7	Be -119.6	Be -108.3	
Mg -130.8	Ca -126.0	Ca -113.3	
Be -131.3			
Ca -138.2			

\*Quartz    †Rutile    ‡The dioxide, UO<sub>2</sub>

sustaining, and should produce a sufficiently high temperature that xy and M can appear as separate phases.

### Thermochemistry

Theoretically, the driving force of a reaction is the change in free energy. In recent years, curves and tables have been published for many important chemical reactions which show conveniently the variations of this quantity with temperature, from which one can predict the theoretical efficacy of any reducing agent. (The actual rate of reaction cannot be predicted because it is controlled by many other factors.)

Thus, values for the free energy of formation of oxides (symbolized as MO) have been listed at various temperatures in Table I, copied from the earlier article. In theory, at the conditions of temperature and pressure at which the data apply and the calculations are made, a metal will displace from its oxide any metal above it. The further apart the metals in the listing, the greater the driving force of this reaction.

It will be seen at once that the order of the metals changes notably as temperature increases. This is due in part to the marked difference in their respective boiling points. Thus, at 227° C. zinc will reduce iron oxide, their respec-

tive free energies at that temperature being -71.3 and -55.5. However, at 1227° C. and higher the opposite is the case. (This situation occurs in zinc smelting. In the horizontal retort process for zinc, iron in the ore is reduced before zinc, while in the slag fuming process for zinc, iron oxide at 1300° C. is not reduced but zinc is readily reduced and comes away as a gas.)

Table I also shows that magnesium is a powerful reducing agent, but loses place at higher temperatures. Calcium remains at or next to the bottom of this scale at all practical temperatures and theoretically will reduce all oxides above it at standard conditions.

The table also emphasizes that sodium is a relatively poor reducing agent for oxides and at higher temperatures sodium oxide should be readily reduced by all the common metals, being at the very top of the list at 1727° C.

A similar list for chlorides appears in Table II. Notable differences between chlorides and oxides are the higher numerical values for metals and the greatly improved position of sodium which now occupies a place near calcium at elevated temperatures.

This advantageous theoretical position is lost to some extent in practice, owing to the high vapor pressure of sodium.

Table III shows the fluoride list. Fluorides show even higher numerical values than chlorides. Calcium maintains its supreme position. Sodium and magnesium are fairly close together, but aluminum is well up in the column.

While these figures for free energy give an indication of the driving force of the reduction

**Table II—Free Energy of Formation of Chlorides  
(per Cl<sub>2</sub>)**

(Approximate values taken from curves of K. K. Kellogg, *Journal of Metals*, Vol. 191, 1951, p. 137)

0° C.	500° C.	1000° C.	1500° C.
Cu -54	Cu -42	Cu -33	Cu -22
Ni -64	Ni -48	Ni -33	Ni -38
Si -68	Fe -57	Fe -48	Si -43
Fe -72	Pb -58	Pb -48	Pb -50
Pb -76	Si -61	Si -53	Fe -52
Ti -82	Ti -73	Ti -66	Ti -58
Zn -89	Zn -74	Zn -68	Zn -60
Be -102	Mn -91	Mn -79	Mn -76
Zr -104	Zr -92	Zr -85	Zr -78
Mg -142	Mg -123	Al -102	Mg -88
	Na -163	Mg -108	Al -99
	Ca -164	Na -140	Na -111
		Ca -148	Ca -136

reaction, they permit no prediction as to speed of reaction nor temperature of initiation. Nevertheless, it does indicate likely and unlikely reactions, although even this is not reliable if the activity is unknown. (For example, under special conditions calcium metal can be produced by the reduction of  $\text{CaCl}_2$  with sodium, whereas the opposite would be assumed from the fact that sodium is above calcium in all columns in Table II.) Nevertheless, useful preliminary predictions can often be made. Thus



goes readily to the right under almost all conditions; there is a large difference in the free energy of formation of the two chlorides at operating temperatures. The reaction between Mg and  $\text{FeCl}_2$  is likely to be violent, while  $\text{Al} + \text{MgCl}_2$  is a poor possibility. These predictions are borne out by experiment.

One other observation about heat of reaction should be made here: When one or more of the reactants is to be as a liquid, a high heat of reaction is desirable in order that the reaction be self-sustaining and result in a clean separation of reactants. The latter depends partly on low viscosity of the liquids, and viscosity decreases as the temperature is raised.

We can sometimes increase the temperature of the reaction by oxidizing some excess reducing agent. Thus, Spedding and Doan add iodine to the mixture when reducing certain fluorides; the iodine combines with calcium and makes a substantial contribution to the over-all heat of reaction:



If this scheme is used, it is well to aim at the highest state of oxidation of the metal compound, although at times this is a mixed blessing since

Table III - Free Energy of Formation of Fluorides (per  $\text{F}_2$ )

(Approximate values taken from Kellogg's curves)

0° C.	500° C.	1000° C.	1500° C.
2HF -131	2HF -129	Pb -116	Cd -94
Pb -148	Pb -132	Ca -119	Pb -108
Co -155	Co -139	2HF -128	2HF -127
U -162	U -152	U -140	Al -151
Mn -180	Mn -163	Al -160	Si -154
Si -180	Si -173	Si -165	Mg -184
Al -197	Al -178	Na -207	Li -207
Mg -251	Mg -231	Mg -211	Ca -207
Na -259	Na -234	Li -232	
Ca -279	Li -256	Ca -240	
Li -280	Ca -259		

it increases the volume of salts or slag which form at the end.

The melting points and boiling points of  $\text{My}$ ,  $\text{x}$ ,  $\text{xy}$  and  $\text{M}$  should be such as to move the reaction toward the right under practical working conditions, and at the same time effectively separate the desired metal  $\text{M}$  from products and reactants. For a given  $\text{M}$ , this vital requirement greatly restricts the choice of  $\text{y}$  and  $\text{x}$ .

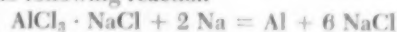
The most effective method of separating the wanted metal from the reactants and other products is the formation of a new phase. The best situation exists when the wanted metal only is a gas at the reaction temperature and is removed from the system by distillation. Unfortunately, the only common metals behaving thus are the alkali and the alkaline earth metals themselves—usually the very reducing agent we desire to use. (Sometimes the product  $\text{xy}$  can be removed as a gas—for example,  $\text{MgCl}_2$  produced in the Kroll process for titanium.)

The next best, and most common, case is where one or both of the reaction products are liquids of very different densities. The "classical" instance is the so-called thermit reaction in which a mixture of iron oxide and powdered aluminum is ignited; iron is the desired product and the resulting  $\text{Al}_2\text{O}_3$  is generally rendered liquid by a suitable slag-producing material in the original mixture. Thus, the end product at 2000° C. is the heavy liquid iron on which floats a lighter insoluble liquid slag.

Oxide reductions with magnesium or calcium are generally unfavorable. The melting points of the products,  $\text{CaO}$  and  $\text{MgO}$ , are impossibly high and few acceptable slagging agents are available. The halides can sometimes be used for a flux as they exert a small solubility for their oxides. Thus,  $\text{CaF}_2$  dissolves  $\text{CaO}$  to some extent.

If chlorides rather than oxides are to be reduced, the reactive metal itself may be soluble in its chloride. For example, work by Cubicciotti indicates that magnesium is soluble to the extent of 1.2% in its chloride at 900° C. The value for calcium under similar conditions is 16%.

Chlorides and fluorides frequently have great advantages since they generally have reasonable melting points. Thus, St. Claire Deville was able to produce aluminum in an entirely liquid system by the following reaction



and since the liquid aluminum is insoluble in the liquid chlorides and is less dense, a fairly effective separation was achieved.

In a somewhat similar way, beryllium may be

produced by magnesium reduction of the fluorides, and the beryllium separated from a liquid  $\text{BeF}_2 \cdot \text{MgF}_2$ .

Titanium offers no opportunity for liquid separation in the oxide system, and the  $\text{CaO}$  or  $\text{MgO}$  residues must be removed by leaching, leaving behind a powdered titanium. In chloride systems, a solid porous titanium separates poorly from liquid  $\text{MgCl}_2$ , but the latter may be distilled off.

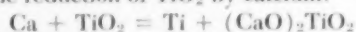
Where high temperatures are required in the presence of magnesium (or even calcium), it may be desirable to conduct the reaction under pressure. Usually some type of "bomb" is employed, the system is filled with inert gas, and the pressure results from the expansion of this gas as the reaction mass heats up. Any volatile components will of course contribute to this pressure.

#### Alloy Formation and Reactions

In the ideal reaction  $\text{My} + \text{x} = \text{xy} + \text{M}$ , the metals  $\text{M}$  and  $\text{x}$  do not form alloys and compounds, and  $\text{My}$  and  $\text{xy}$  are mutually insoluble.

Unfortunately, this state of affairs is seldom attained; especially in the chloride and fluoride systems,  $\text{My}$  and  $\text{xy}$  frequently form a range of lower melting mixtures. Thus, almost all alkaline earth and alkaline metal chlorides form eutectic mixtures. Furthermore, the activity of  $\text{MCl}_2$  is reduced when in solution in  $\text{CaCl}_2$  (for example). Sodium will reduce  $\text{CaCl}_2$  to produce a mixture of  $\text{Na-Ca}$  alloy and  $\text{CaCl}_2 \cdot \text{NaCl}$ ; the alloy must be treated with pure  $\text{CaCl}_2$  to displace the equilibrium until a calcium-rich alloy is obtained.

In oxide systems, the formation of complex oxides is often a hazard to the complete reaction, as in the reduction of  $\text{TiO}_2$  by calcium:



We can sometimes prevent such an undesirable reaction by adding a compound which "ties up" the product of reaction. Thus, in the production of magnesium by the silicon reduction, the presence of  $\text{CaO}$  prevents this reaction of  $\text{MgO}$  and  $\text{SiO}_2$ :



Alloying between the reducing agent and the metal produced cannot be prevented where the tendency exists, and frequently the choice of reducing agent is greatly restricted by this phenomenon. Thus, in the production of cerium by reduction of the fluoride, Gray chose lithium in place of the cheaper calcium because the latter formed alloys with cerium. Spedding overcame this difficulty with calcium by subsequently distilling the calcium from the  $\text{Ca-Ce}$  alloy.

#### Reaction and Initiation Temperatures

When a reaction has been selected which fulfils theoretical requirements as regards thermochemistry, equilibrium displacement and the other conditions mentioned above, the rate will still be controlled by the accessibility of reactants. When the latter are high-melting, nonvolatile solids, they must be present in the mix in a fine state of subdivision. Magnesium and calcium can now readily be so produced.

When reaction takes place between a liquid and a solid, there may be a satisfactory basis of access, each to each, and all the reducing agents under consideration possess low melting points. At most reaction temperatures, magnesium and calcium exert very appreciable vapor pressures and a gas-solid or gas-liquid mechanism is possible and likely.

The reactant  $\text{My}$  may be volatile as in Kroll process titanium where gaseous  $\text{TiCl}_4$  reacts with liquid  $\text{Mg}$ . The reaction rate is controlled by the rate of addition of  $\text{TiCl}_4$  gas.

Autogenous reactions are initiated by locally heating a part of the charge; on the other hand, the whole mass may be gradually heated until the reaction is initiated. In the last mentioned, the higher the temperature achieved before ignition the higher, obviously, the final temperature will be. Thus, an "assisted shot" should be heated up slowly and evenly to avoid premature ignition. If a high reaction temperature is undesirable, a small reaction mass will be used, and it will be ignited by a "fuse" from room temperature.

#### Conclusion

This concludes the second portion of our general review of the scientific fundamentals underlying the production of the "new" or reactive metals of growing industrial importance.

In the first installment (August), the four means of reducing metal from minerals or chemical compounds were briefly analyzed. In this second installment we have considered only one of these — namely, the displacement of one metal by another — and outlined the various limitations set upon this method by such things as the relative values of free energy of formation of the compounds involved (ordinarily oxides or halides), the melting and boiling points of the reactants and the products, and their miscibility at the temperature and pressure of the operation.

In the concluding installment, some actual examples of industrial exploitation of these general scientific principles will be noted.

# Selection of Heat Treating Process and Equipment

By E. J. PAVESIC and R. T. SINNOTT\*

Automation of heat treating departments offers some advantages but also some pitfalls. Some of the factors which must be considered in deciding between batch and continuous heat treating equipment are discussed. (J general)

**S**ELECTION OF THE BEST heat treating method and equipment for a particular component has become increasingly difficult because of the demand for both lower production cost and superior engineering properties in the treated part. Cost must be reduced not only by eliminating as much labor and heat treating time as possible but also by using the least expensive steels that can provide the properties required. The quality of the product must be both high and uniform.

The ideal solution would be to build an automatic heat treating installation for each component to be processed. With completely automatic control of temperature, atmosphere, cycle time and quenching conditions, the quality should be consistent. Mechanization of loading, unloading and flow of the charge through the furnace would reduce labor costs and give better quality.

Unfortunately few heat treaters can amortize the cost of automated equipment in their normal operations. Furnaces usually must be adaptable to a number of different parts of various analyses which require entirely different treatments. For example, the heat treating department of a business machine manufacturer has to process gears, shafts, small levers and a number of other parts. The gears must be tough and wear resistant so they will probably be carburized and hardened.

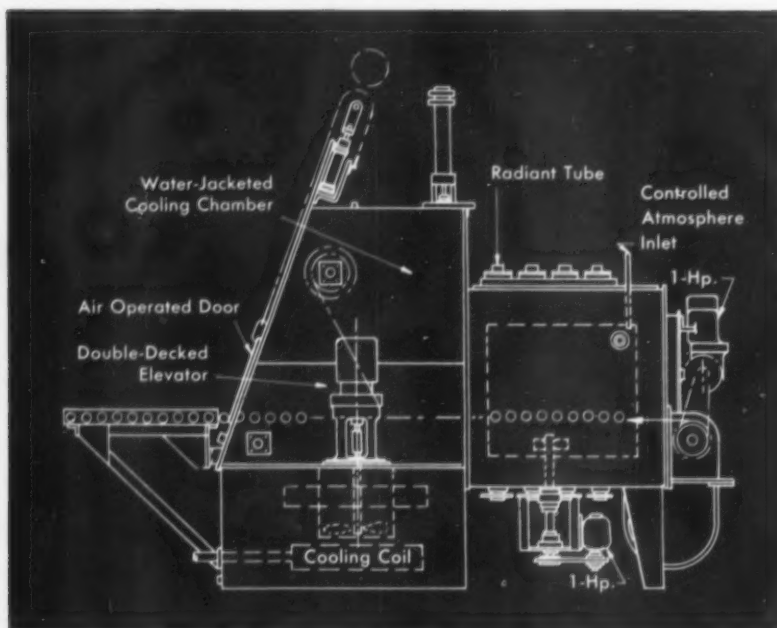
\*Field Metallurgist and Methods Engineer, respectively, Lindberg Steel Treating Co., Melrose Park, Ill.

Shafts must be strong and tough and will be hardened and tempered. The levers require only a wear resistant surface with low unit loading so they may be given a shallow case either by liquid case hardening or by carbo-nitriding.

The above illustrations indicate the types of processing which will fulfill the engineering requirements but do not firmly establish the specific types of equipment which will impart the properties most efficiently. Before the type of heat treating equipment can be selected, consideration must be given to the design of the part, its mass and over-all dimensions. For example, small flat washers which require case hardening on all surfaces could only be processed in baskets in a liquid bath, in a rotary retort type furnace or by pack carburizing. Any other method or equipment which might ordinarily be used for case hardening would produce a nonuniform case and spotty hardness.

The case hardening of small screws would require the same methods of processing although shallow layers can be carbo-nitrided to uniform depths of case, because the design of screws generally would prohibit intimate contact of adjacent screws. Pack carburizing of small screws presents handling problems which make it desirable to use the other methods. Reciprocating or shaker hearth furnaces could also be used.

If the part to be heat treated is complex in shape, such as a gasket die made of toolsteel which requires extremely close control over di-



*Batch-Type Atmosphere Furnace. All operations except loading and unloading are automatic*

mensions and warpage, the probability is that it will have to be martempered and straightened while in the temperature range of martensite formation. Such individual handling obviously limits the type of equipment which can be used.

Knowing the engineering requirements of the part and the limitations imposed by the design, the next factor to consider is the quantity of production required. Job-shop production where the product is diversified from the standpoint of design, analysis, mass and use, requires batch-type equipment. For example, the heat treatment of tools, dies, jigs and fixtures from many materials would of necessity require batch-type equipment. Tool and die materials have a processing temperature range of 1400 to about 2400° F. It is difficult under such broad variations in temperature to use one furnace over the entire range. The general practice is to employ several furnaces, one, for example, for temperatures from about 1400 to 1900° F. and the other for temperatures from about 1900 to 2400° F. Preheating furnaces operating to temperatures of 1200° F. are often used in conjunction with the austenitizing furnaces.

Such job-shop production as encountered in the manufacture of tools and dies also necessitates the use of special heating, quenching and tempering cycles so that the furnaces used for hardening are usually separate from the quench-

ing and tempering equipment. Automation and even mechanization are difficult to achieve under such circumstances. However, furnaces have been designed and manufactured which incorporate preheating, austenitizing and quenching zones in an "L" shape with all zones under atmosphere control and protection. Such furnaces are useful in the processing of steels which harden at slow rates of cooling. They can also be used for preheating and austenitizing or austenitizing only of steels which require liquid quenching. Since such furnaces perform the operations which might normally be performed by two furnaces, there is a definite saving of floor space and fuel and handling cost. Improvements in quality are realized by the elimination of contact of the work with air when transferring from furnace to furnace or furnace to quench.

The volume of heat treated product, even though large, may not justify the use of automatic or continuous equipment because of the great diversity of sizes, analyses, engineering requirements and production demands. For example, one commercial heat treater processed in a three-month period 651 lots of carbon and alloy steel with a total weight of 920,827 lb. Normalizing or annealing for grain refinement and improved machinability was required on 101 of these lots. They included cast, forged and hot

rolled gear blanks with a broad range of analyses, designs, sizes and quantities. The minimum lot was two bars with a total weight of 80 lb., the maximum was 400 gear forgings with a total weight of 31,600 lb.

The larger lots were processed in a continuous single-zone pusher furnace. Small product lots which could not be combined with the larger lots for processing in the continuous pusher furnace were treated in small batch-type semi-muffle furnaces, manually operated. Where full annealing to a completely spheroidized microstructure was required, it was carried out in forced-convection pit-type batch furnaces.

During the three-month period 255 lots of hand tool components were hardened and tempered. Some of the lots were so small that they were processed in batch-type atmosphere furnaces. Others were large and warranted processing in continuous vibrator hearth or belt conveyor-type furnaces. Tempering was performed in batch-type forced-convection furnaces. Continuous tempering is not feasible unless the chemistry and hardenability and consequently the tempering characteristics of the steel are closely controlled or unless entire heats are involved.

On parts that required carburizing, the specified case depths varied sufficiently so that product lots had to be separated into batches according to case depth. The necessity for control of other properties such as dimensions, warpage, case and core hardness and microstructure made batch-type processing mandatory. The parts were processed in pit-type gas carburizing furnaces and those items which were not direct quenched were cooled in a separate cooling pit and subsequently reheated for hardening in (a) a mechanized batch-type atmosphere hardening furnace with integrated quenching facilities, (b) a neutral salt bath with various quenching mediums available including hot salts for martempering, or (c) in a manually operated batch-type atmosphere furnace where die quenching or selective quenching was required. When the volume of production of a given part is so great that no existing equipment can produce the engineering requirements at a reasonable and competitive cost, new equipment or modification of the old must be considered. Since the productive capacity of one or more large continuous furnaces can be equaled by the use of a greater number of batch-type furnaces the final selection may be influenced by the following factors:

1. The risk of scrapping large quantities of parts in a large continuous furnace because of a

furnace failure. The value of the part will determine the importance of this factor.

2. The possibility of interrupting the steady flow of work from the heat treating department to the machining or assembly lines. If one of many batch-type furnaces is shut down for repairs, only a small percentage of production is lost.

3. Batch-type furnaces are more adaptable to changes in production volumes and are more capable of accommodating changes in design, mass, size and engineering requirements of parts than are large continuous furnaces.

4. Large continuous furnaces are generally constructed on the site and take longer to build. Batch-type furnaces are considered to be standard items and therefore are manufactured in greater numbers making them more readily available. Their design and engineering costs are reduced considerably. Installation of batch-type furnaces takes less time than that required for semicontinuous or continuous furnaces.

5. Batch-type furnaces provide greater versatility from the standpoint that they can be moved more readily to new locations within a plant. Closer integration with production lines can thus be accomplished.

Some of the advantages of continuous furnaces which affect cost and the final selection are:


1. Continuous high-production furnaces are capable of providing a steady flow of work with a minimum of labor.

2. In continuous gas carburizing two, three, four or more rows of work can be processed at varying speeds to produce different case depths simultaneously.

3. Continuous production furnaces with automatic controls tend to reduce rejections attributable to human errors.

4. Automatic controls on large continuous furnaces provide consistently uniform results which reduce inspection requirements.

5. Continuous furnaces provide greater heating efficiency.

With the many variables which influence the selection of heat treating equipment the final selection should be based upon detailed cost analyses of the several methods by which the heat treatments can be performed. Personal preferences for or against any equipment or method should not be allowed to influence the selection unless supported by factual data. Methods used for calculating the cost of heat treating are shown in the Metals Handbook, 1954 Supplement, p. 125. Based on such analyses, sound decisions can be reached in the selection of equipment. 

# National President, American



**Donald Sherman Clark**  
Professor of Mechanical Engineering  
California Institute of Technology

# Society for Metals, 1956-57

ONE of the most ardent proponents of a thorough training in basic science for young men entering the field of engineering is Donald S. Clark. While Professor Clark's primary interest is in physical metallurgy, his greatest pleasure is found in his contacts with students. It is impossible to estimate how many of them, both undergraduate and graduate, he has stimulated to greater heights in their education.

Don Clark received his Bachelor of Science degree in Engineering in 1929 from California Institute of Technology. His career in education started as a graduate teaching assistant and continued on a part-time basis until he received his Ph.D. degree in 1934. He was then made instructor in mechanical engineering and has progressed continuously through the academic steps to his present position as professor of mechanical engineering at CalTech.

Most of Dr. Clark's research activities in recent years have been concentrated on the dynamic behavior of metals and alloys, and in 1953 he delivered the Edward deMille Campbell Memorial Lecture for the American Society for Metals on "The Behavior of Metals Under Dynamic Loading". In recognition of his work in this field, Professor Clark has received the Richard L. Templin Award and the Charles B. Dudley Medal from the American Society for Testing Materials.

Many other subjects have also come under his attention during his long career at CalTech. The subject of his Ph.D. thesis was the iron, iron carbide, iron boride system. He has conducted and supervised research on silver and its alloys, fluoroscopic inspection of metals and alloys, and wear of metals. During his early years at CalTech, he assisted Prof. William Howard Clapp in establishing the University's first courses in physical metallurgy. Since 1954 he has been a member of a Project Advisory Committee of the Ship Structure Committee for the National Academy of Sciences.

Dr. Clark's combined interest in educational principles and physical metallurgy naturally led him into the preparation of textbook material. Two books have resulted — "Engineering Materials and Processes", written in collaboration with the late Prof. W. H. Clapp (first edition 1938, second edition 1950), and "Physical Metallurgy for Engineers", written in collaboration with W. R. Varney, former assistant professor of mechanical engineering at CalTech, and published in 1952. In addition he is the author of some 30 published technical papers.

Professor Clark was born on Dec. 27, 1906 in Springfield, Mass. He moved to Burlington, Vt., at the age of ten, where he received his education through high school. Professor Clark's father was a successful business man, but early recognized his son's bent toward engineering and encouraged it. In 1925 Don moved with his parents to California,

where he entered CalTech. He now owns his own home in San Marino (near Pasadena), where he lives with his mother.

Professor Clark attracts additional duties like a magnet, and has taken a heavy share of administrative affairs at CalTech along with his teaching and research activities. He has been director of placements for the Institute since 1935, devoting much time to students' employment problems. As secretary of the faculty in mechanical engineering, Professor Clark looks after certain phases of administrative problems. His activities in the Alumni Association have included a two-year term as a director, and he has served as secretary of the association for the past ten years. He has also had a four-year tour of duty as editor-in-chief of *Engineering and Science*, the Alumni and Institute's monthly magazine.

Dr. Clark joined the Los Angeles Chapter of  $\Phi$  in 1930 and was chairman in 1936-37. He has presented several lecture series for the chapter. He was a national trustee of the society for the two-year term 1939-1940 and was elected national vice-president in 1955. He served as program chairman of the Western Metal Congress in 1938 and again in 1941. He is a member of numerous other technical societies, Tau Beta Pi and Sigma Xi.

With all this, Dr. Clark still finds some time to devote to the art of bookbinding, and is proud of his complete collections of various technical society journals — including a set of *Metal Progress* starting with the first issue in 1930 — neatly stitched together in yearbook form. He also dabbles in the collection of antique microscopes and growing of camellias.

Coming under the influence of the Nobel laureate, Dr. Robert A. Millikan, he could not help but be stimulated toward a career of leadership and a firm belief in the importance of fundamentals of engineering and science combined with an adequate training in the humanities. Dr. Clark believes that one of the biggest problems of the engineer and scientist is working with other people. He deplores any attempt at early specialization in college and believes that any major specialization should come in graduate work or in industrial practice after a man has received his B.S. degree.

Those who work with Dr. Clark day by day recognize the strong drive that he possesses and the perfection and labor that he expects of those who work with him. His students regard him as a demanding teacher, but a fair one — a taskmaster who maintains high standards in classes. This is somewhat reflected in the nameplate that rests on his desk and greets the visitor with the name "Simon Legree". In spite of this apparent pressure, he is generous and kindly and the implication of this label is counterbalanced by the nickname of "Butch" given to him by some of his early students, and the now more prevalent and familiar "Doc".  $\Phi$

# Radial Draw Forming of Helicopter Components

By L. FAVREAU\*

**P**RODUCTION of helicopters is much like production of other aircraft. Few of the individual components are simple in shape, most have complex contours and all have tight dimensional tolerances. Economical fabrication of such components is difficult because of the large variation in sizes and shapes required and the limited volume of production involved.

When Kaman Aircraft Co. received its first large order for the HOK-1 twin-rotor helicopter, the tooling problem was especially acute. The company was new and had comparatively few tools and limited capital. Many of the parts of the first few models had virtually been formed by hand and a more economical and faster production method was essential. The parts range in length from 8 in. to over 15 ft. and include channels, hat sections, Z-sections and, in at least one instance, a cross section that varies in size along the length of the component.

Our analyses indicated that the most versatile equipment we could obtain was a radial draw former made by Cyril Bath Co. With it we could perform regular stretch forming operations plus rise and fall work, 360° or even spiral forming and compression forming. In the radial draw former, the die is mounted on a rotary table. The part is gripped at one end by a gripper head actuated by a hydraulic cylinder and affixed to the table so that it turns with the table. The other end is held by a second gripper head, also hydraulically actuated, but mounted on an

Radial draw forming equipment is sufficiently versatile that it can be used to fabricate inexpensively many of the complex shapes used in helicopters. (C 9)

independent bed. The piece to be formed is first stretched beyond its yield point between the gripper heads and then the die on the rotary table is turned into the piece, causing it to take the configuration of the die. The die itself imparts an additional stretch and since the forming takes place radially, or a line at a time, considerably less stretch tonnage is required than in stretch-wrap forming where a piece is being stretched as a whole.

About 25 different parts for the HOK-1 are now being made on the radial draw former. The most obvious economy has been in the virtual elimination of all bench work on these parts, and in addition, production rates have increased and dimensional accuracy has improved.

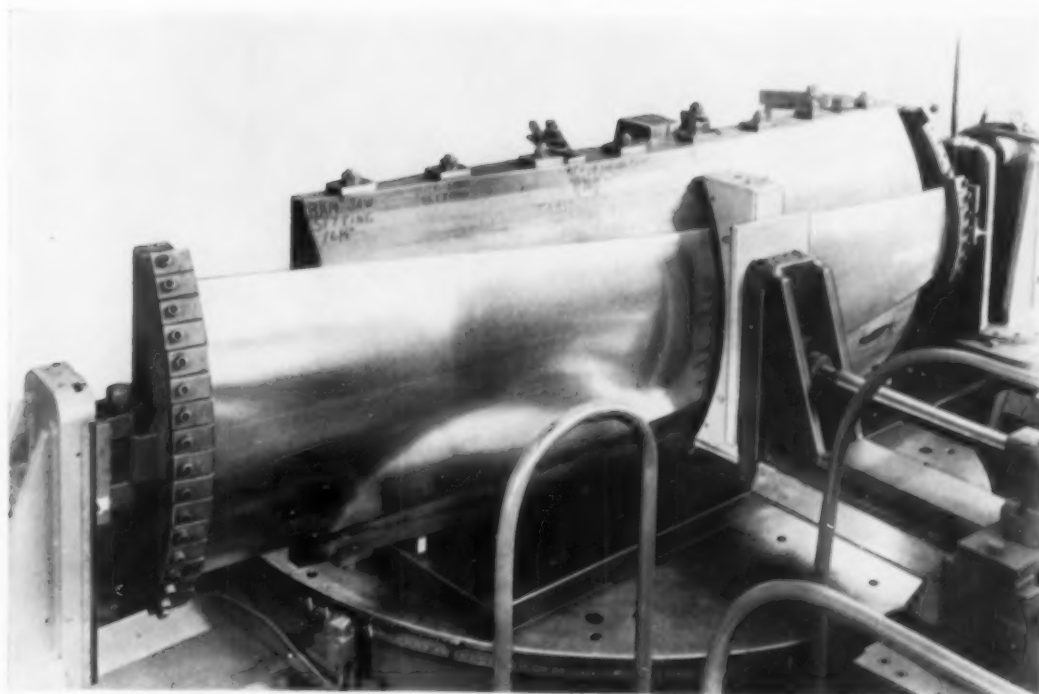
One example of the kind of savings that were realized is the fabrication of the tapered leading edge of the rotor blades which has a reversed flaring near the hub end. The part is 15 ft., 2 in. long and is made from half-hard 0.015-in. Type

*In Radial Draw Forming, the Blank Is Stretched Between Jaws and the Die Is Turned Into It. The traversing wipe shoe permits closer control of stretching pressure or may be used for compression forming*

\*Chief Tool Engineer, Kaman Aircraft Corp., Bloomfield, Conn.



*Radial Draw Forming Solved Fabrication Problems  
on 25 Parts of the HO4S-1 Twin-Rotor Helicopter*




301 strip. The radius of the nose of the piece is  $3/16$  in. at the tip and increases to  $15/32$  in. at the hub. When formed it is bonded to the wooden rotor blade to protect the surface and to add strength to the blade.

The original method of forming was a five-stage operation that required considerable hand work. The blank was first rolled into an open clam-shell contour and then the nose radii were formed on a press brake. The male die was shaped to final contour; a 1-in. thick rubber pad retained in a 6-in. channel served as the female die. The desired cross section was approximated in the process but the metal wrinkled badly. To eliminate the wrinkles and straighten the part it was stretched on a stretch press without any dies. The amount of stretch varied and often excessive localized thinning occurred in adjacent areas that had been heavily wrinkled.

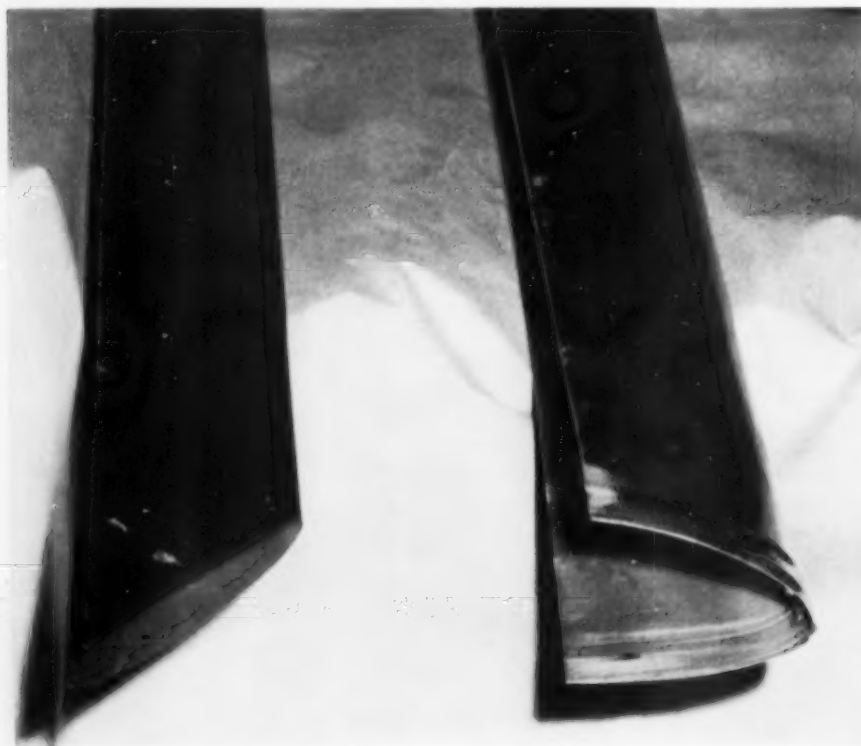
After stretching, the part was turned on its side and hit between two flat dies in a press brake in order to close up the cross section a little more. Finally, it was reworked by hand to correct inequalities and to put in the flaring of the contour near the hub end of the blade. No more than six

leading edges could be produced in a day and often unsatisfactory bonding and spring constant checks could be traced to irregular contoured leading edges.

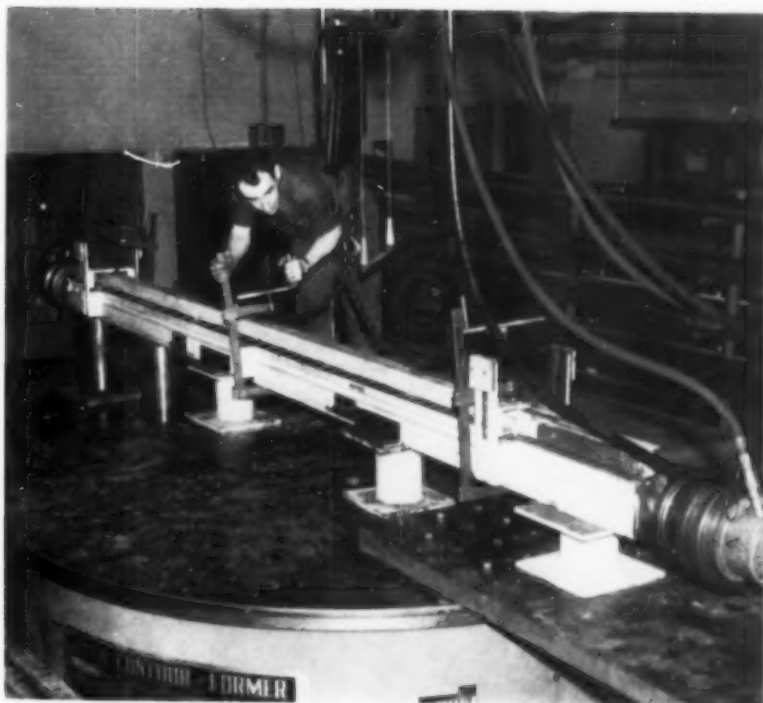
With the radial draw former, the leading edges are now produced in one operation at a rate of four per hour. No hand work is required, and localized thinning, which had previously been a serious problem, is now held to less than 0.0005 in. Both a male and a female die are used and they are made from epoxy resin and fiber glass to reduce tool costs.

The flat blank is placed on the female die which is positioned between the two gripper heads. The male die is lowered and clamped into position with three C-clamps tightened manually. There are bottoming cushions placed every 2 ft. along the female die to provide 0.005-in. clearance between the dies for slippage during the stretching operation. The part is then stretched 11 in. between the gripper heads and withdrawn from the dies. No hand work is necessary and it has been found that rejected sections formed faultily by the previous method may be salvaged in this operation. 

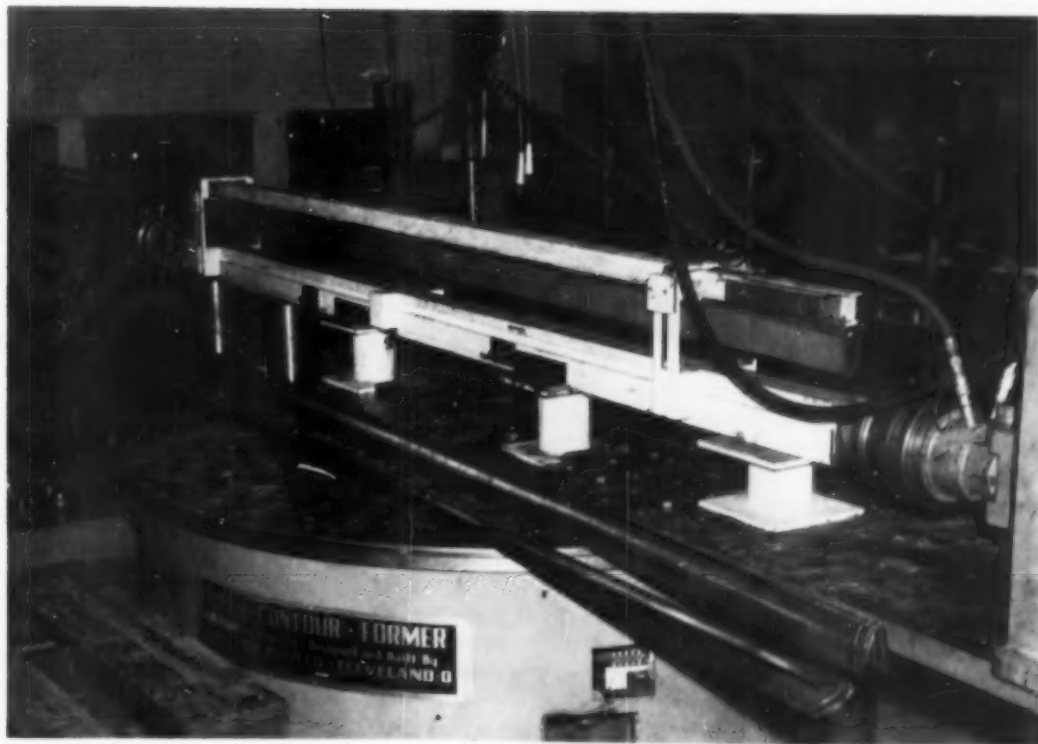
*Opposite Ends of the Leading Edge Indicate the Change in Cross Section Along Its Length*



*The Male Die Is Clamped  
Into Position to Control  
Contour of the Rotor  
Blade Leading Edge*



*Leading Edges Are Formed Five Times Faster and  
More Accurately With the Radial Draw Former*



# Expendable Molds for Titanium Castings

By A. L. FEILD, JR.\*

Titanium castings can be produced free of internal porosity and with negligible surface contamination in molds made from a new graphite-base mixture. (E 18, Ti)

**M**ANY TITANIUM and titanium alloy components which are now produced by forging or machining would be cast if they were made of any of the conventional structural materials. Castings would be appreciably less expensive and would increase the number of applications for which titanium could be justified economically. Because titanium is so reactive with the atmosphere and the usual refractories, however, the standard foundry techniques for melting and casting cannot be used.

There are two distinct problems involved in titanium casting. The first is selection of the melting technique and the second is the development of a suitable mold material to minimize contamination. The melting problem has been studied sufficiently so that metal can be melted out of contact with refractories through the use of skull techniques. For corrosion resistant applications, alloys with satisfactory chemical properties but relatively low ductility can be obtained using comparatively low-cost induction melting techniques. For maximum ductility, expensive vacuum skull melting must be employed.

Since no refractories are completely inert to molten titanium, the choice of a mold composition resolves itself to those materials which cause minimum contamination and porosity during the

contact between molten metal and refractory surface in casting operations. There is little contamination of the metal when machined graphite molds are used but mold preparation is slow and costly. The molds can be used only a few times and are limited to simple shapes. For economical foundry practice, the mold must be expendable and amenable to commercial techniques.

We investigated thoroughly all conventional oxide refractories and molding techniques and found none of them satisfactory for titanium castings. We finally decided to use graphite as a base material but in powder form to circumvent the disadvantages of the machined product and to produce a mold which is unreactive, inexpensive, need be used only once and can be molded to produce any desired shape. The selection of the proper powder sizes and the development of a suitable combination of bonding agents for these powders constituted an exhaustive testing program which covered all classes of organic and inorganic materials that could even remotely be classified as binders. The materials are compounded with water and a special surface-active agent which reduces by one-third the amount of water needed for molding. The resultant damp mold mixture can be pressed over a suitable pattern. The best composition is 53% electric furnace graphite powder (-20 + 100 mesh), 10% dry corn starch, 10% pulverized pitch, 8% carbonaceous cement, 1% sur-

\*Metallurgist, Pigments Dept., Experimental Station, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

face-active agent ("Duponol" G fatty alcohol amine sulphate), 18% water.\*

The cornstarch acts as a "green" or low-temperature binder which permits molding at room temperature and develops considerable strength. Other materials tested did not develop sufficient bond strength or else caused pattern sticking. Pitch and carbonaceous cement in combination form a solid high-temperature bond when the mold is fired. The use of either of these components alone does not produce smooth mold surfaces or results in poorer resistance to spalling. The surface-active agent makes the starch-graphite system compatible and permits thorough blending of liquid and dry components. It also reduces the amount of water necessary. All solid components are carbonaceous and reduce to elemental carbon upon high-temperature firing. This produces a mold free of oxygen and nitrogen-bearing compounds which could cause contamination and embrittlement of the cast metal.

The process of mold manufacture involves only a few basic steps, all of which are performed with equipment available to most foundries. The graphite powders are blended dry with the starch and pitch in a commercial cone blender. The carbonaceous cement and surface-active agent are thoroughly mixed with the water in a separate container. The dry mixture is placed in a muller and the liquid components are added slowly while the muller is in operation. After suitable mixing, the damp mass is removed from the muller and hand-tamped around wood or metal patterns which have been previously coated with a parting agent. The mold and pattern assembly is then pressed in a hydraulic press at pressures from 50 to 85 psi. The mold is stripped from the pattern and allowed to dry at room temperature from 8 to 72 hr., depending on size.

Residual water is removed by drying in an oven whose temperature is increased gradually from 140 to 250° F. over a 48-hr. period. The mold is then fired at 1200 to 1650° F. for 1 to 2 hr. in an electric furnace. The mold is enclosed in a steel box with a graphite lid to prevent oxidation during firing. Molds so produced are hard and permeable and can be handled without danger of breakage. The mold shrinkage averages about 3/16 in. per foot of length, which is not an excessive amount.

A number of unalloyed titanium castings ranging in weight from ½ to 8 lb. and in section thickness from ¼ to 2 in., were made in molds

of this new composition. To furnish a basis for comparison, similar castings were made in molds of machined, dense graphite. The furnace used was of the vacuum arc skull type where the molten charge was held in a solid titanium skull backed with a graphite crucible. The melts were bottom tapped from the crucible directly into the pouring basin of the molds. The mold cavities themselves were bottom-gated from a central sprue in the mold.

Half of a 7-lb. step casting made in machined graphite is shown in Fig. 1. The extremely smooth unreacted surface and the sharp detail are typical of this type of casting. Adequate superheat has produced excellent fluidity and the mold cavity is well filled. A duplicate casting produced in an expendable mold is shown in Fig. 2. No evidence of metal-mold reaction is apparent and the slightly rough surface was due to insufficient superheat in this particular melt. Note the thin, ductile flash along the parting line. An etched cross section of one arm of this casting is shown in Fig. 3. The grain size is uniform and fine and there is no indication of internal porosity. The ductility of a tensile specimen obtained from this casting is also apparent. Such an achievement is significant, for other attempts by various investigators to produce nonporous titanium castings in expendable molds have met with consistent failure.

Castings produced in these expendable molds have exhibited negligible surface reaction. In a 1-in. diameter section, the depth of surface contamination is 0.010 in. from a machined graphite mold and about 0.040 in. when using the expendable graphite powder mold. No greater depth of contamination is shown in 2-in. diameter sections. The hard contaminated layer may be removed by pickling with a 3% HF, 10% HNO<sub>3</sub> solution in water or by sand or steel grit blasting. This contaminated surface layer is no deeper than the oxidized surface layer of many forgings and should cause no concern. The hardness gradients in castings poured in machined and expendable graphite molds are shown in Fig. 4.

The chemical analyses of some 7-lb. castings made in expendable graphite molds and in machined graphite molds are shown in Table I.

Tungsten electrodes were used for melting and an argon-helium mixture for the inert gas. An absolute pressure of 100 mm. of mercury was used during melting. Carbon and nitrogen contents are quite low in both groups of castings. This confirms satisfactory skull operation and furnace vacuum tightness. Hydrogen fluctuates consid-

\*U.S. patent applied for



*Fig. 2 - Step Casting From New Expendable Graphite Mold*

*Fig. 1 - Step Casting Made in Machined Graphite Mold*



*Fig. 3 - Cross Section of Casting Made in Expendable Mold and Ductile Tensile Specimen Machined From the Same Casting*

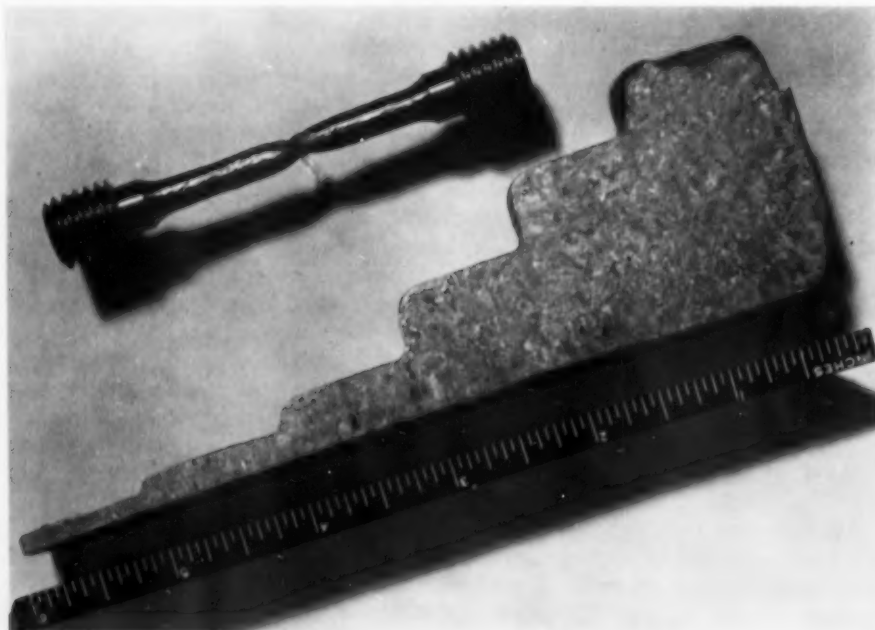


Table I—Composition of Titanium Castings

CASTING NO.	CARBON	NITROGEN	HYDROGEN
Machined Graphite Mold			
1	0.07%	0.029%	156 ppm.
2	0.05	0.020	152
3	0.08	0.013	106
4	0.03	0.014	98
5	0.04	0.019	99
6	0.06	0.029	139
Expendable Graphite Mold			
7	0.03	0.021	147
8	0.04	0.041	195
9	0.06	0.004	95

erably and is probably due to outgassing of interior furnace components during the melting cycle. Improved furnace design and a more elaborate vacuum pumping system would reduce hydrogen to low levels. Vacuum annealing would also remove practically all of the hydrogen.

At equivalent hardness levels, the impact strength, yield strength and tensile strength of expendable mold castings are comparable to those of machined graphite castings (Table II). The elongation of several of the expendable mold castings appeared low for no readily apparent reason so a special low-hardness (Brinell 95) titanium melt was made and a 7-lb. casting of superior quality was obtained in an expendable mold. The cast hardness showed no increase over the sponge charge hardness and the elongation (52%) and impact strength (50 ft-lb.) were extremely good. This test alone proves that very ductile castings can be made in sizable section thicknesses in this new expendable mold.

Some work was done in the laboratory with shell molds and investment molds. The refractories used for making these molds were zirconia, zircon, alumina and silica sands. Shell molds were bonded with 3 to 6% phenol-formaldehyde resin and 5-lb. castings of titanium were made using

Table II—Properties of Titanium Castings

	CASTING NO.*			
	5	7	8	9
Brinell hardness	215	195	205	95
Yield strength, psi.	69,500	68,500	66,500	28,000
Tensile strength, psi.	90,500	84,000	87,000	44,500
Elongation, %	22	9	9	52
Charpy impact, ft-lb.	4	3	3	50

\*Casting No. 5 molded in machined graphite; castings 7, 8, 9 in expendable graphite.

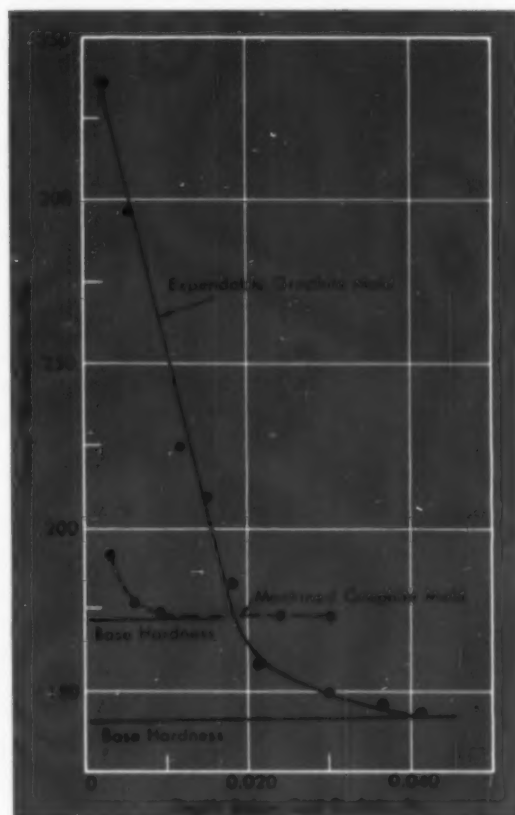


Fig. 4—Depth of Surface Contamination in Titanium Castings

the bottom-gating technique. The castings were very poor, due to reaction of the mold binder and the oxide refractories with the molten metal. Surface contamination was great and internal porosity excessive. Investment molds were made of the same sands using ethyl silicate as a binder. The castings made this way were also highly contaminated from mold reaction, both on the surface and throughout the interior. The relatively poor thermal conductivity of shell and investment molds is a contributing factor to excessive reaction since the surface layers of metal next to the mold wall are not chilled rapidly enough to establish a diffusion barrier.

The production of satisfactory castings depends not only on the mold material but also on the melting practice. Either an electric arc or an induction furnace may be used. The former method, using a consumable or permanent electrode operating on a molten pool contained in a solid skull,

is to be preferred for maximum purity. This system can be operated under high vacuum or with inert atmospheres and there is no contamination from refractory crucibles. However, the furnaces are generally quite expensive and complex. For the production of high-ductility refractory metal castings the vacuum arc melting process must be used.

Induction melting in a graphite or refractory crucible has some merit. Furnaces can be constructed more economically, very large masses of metal can be melted with absolute homogeneity and any superheating necessary can be easily controlled. However, contamination from the crucible can deteriorate the contained metal rapidly unless very close control of melt time and temperature is maintained. The use of a vacuum or an inert atmosphere is necessary. For casting where lower ductility and less critical mechanical properties are acceptable, as in most corrosion resistant applications, this method offers a logical approach to rapid commercialization.

The furnace used to produce the castings in our mold development program is an 8-lb. bottom-pour arc skull melting furnace. Components include a stainless steel tank with sight ports, external resistance heater, graphite crucible, water-cooled tungsten or graphite electrode, mold cavity with mold, two 900-amp. d-c. generators connected in parallel, one mechanical vacuum pump and an inert gas inlet. Necessary meters and gages are installed on the furnace framework. The arrangement is indicated in Fig. 5.

Furnace operation followed the usual procedure for skull melting. Gravity flow was used to fill molds. Tapping was accomplished by melting out the taphole plug with increased power input at the proper moment. Vacuums of  $20 \mu$  with  $2 \mu$  per min. leak rate were obtained with the pump. Graphite electrodes were first considered because they would be economical, amenable to commercial unit scale-up and would not present a tungsten inclusion problem. However, the arc stability was poor and it was difficult to keep the molten pool centered in the skull. Arc penetration was unsatisfactory, and occasionally a melt was contaminated with carbon. Tungsten electrodes produce a more concentrated arc and better melt penetration while skull size and

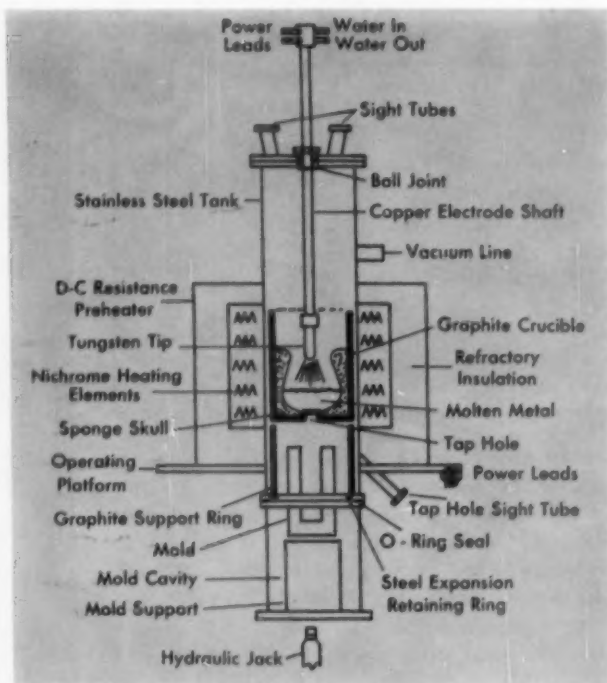


Fig. 5 - Arc Skull Melting Furnace

tapping are easily controlled. Carbon contents of the melts are consistently below 0.08%. No elemental tungsten particles were observed.

It is believed this new graphite powder approach to mold preparation for refractory metal casting may open a large field of application for the type of shapes that have been produced in other metals by sand molding. The limitations on size and shape are not known but this early work shows that 7-lb. melts in section thicknesses up to 2 in. are not affected by mold reaction. The potential uses of castings of titanium or other refractory metals in the small-to-intermediate size range brings many applications to mind. Cast valve bodies, pump housings, fittings and liners for corrosion equipment in the chemical industry are good examples. Items of equipment subject to salt-water corrosion in marine service are other possibilities for castings possessing comparatively low ductility. In the elevated-temperature high-strength field, alloy castings with good mechanical properties would find a ready market. In the military and civilian aircraft industry, in moving machinery parts, or in other places where strength, stability at elevated temperatures and minimum weight are necessary, refractory metal castings would find a very useful place.

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**THE INTERNATIONAL NICKEL COMPANY, INC.**

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# Conversion From Weight Per Cent to Atomic Per Cent in Binary Alloys

By F. FORSCHER  
and W. DEBOSKEY  
Atomic Power Div.,  
Westinghouse Electric Corp.  
Pittsburgh

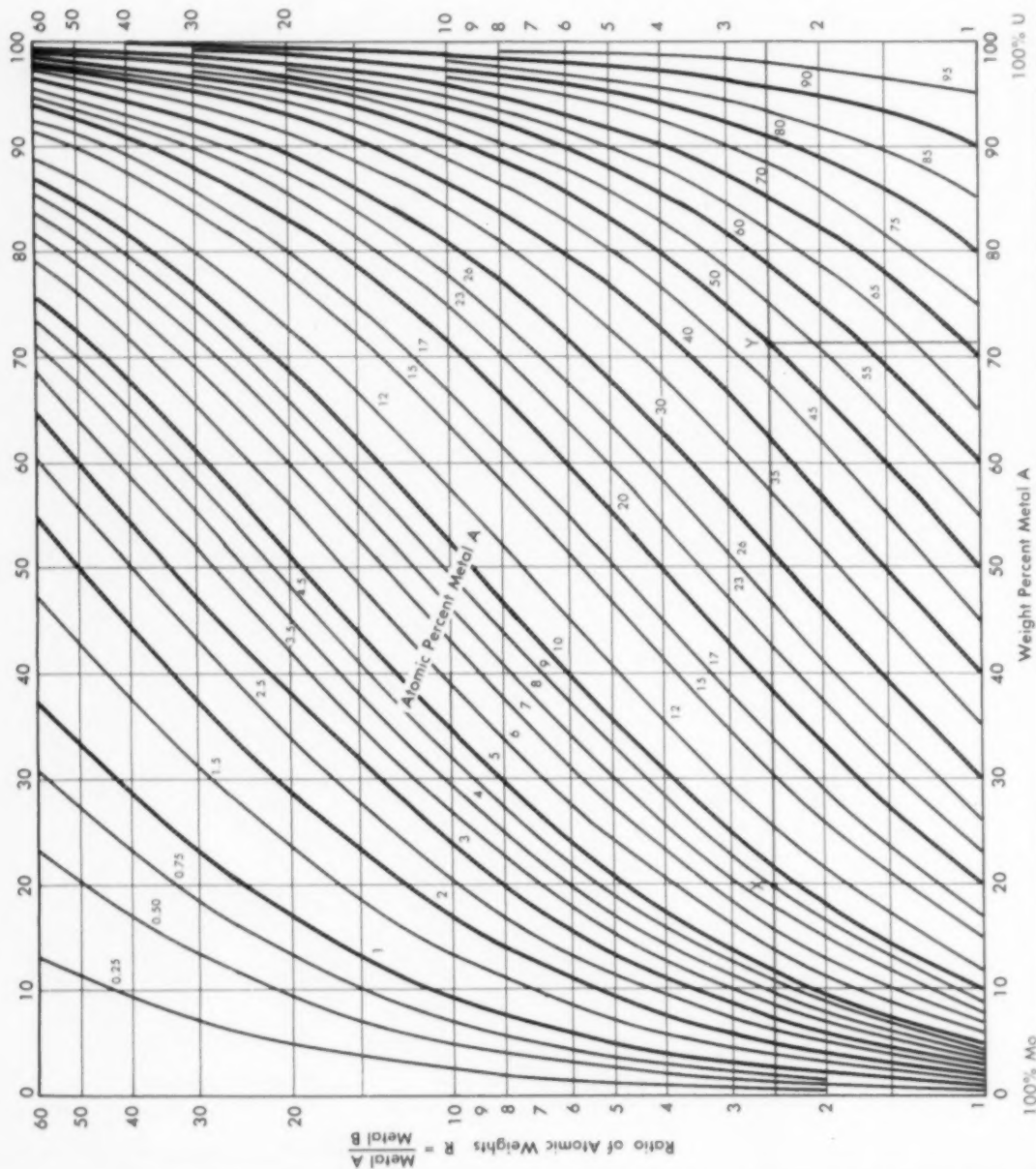
In any binary alloy system, weight per cent can be easily converted to atomic per cent by means of this conversion chart. The only calculation required is computation of the ratio between the atomic weights of the elements.

In the uranium-molybdenum alloy system, for example, the ratio of atomic weights is 238 to 96 or approximately 2.5. A horizontal line is drawn at the  $R=2.5$  level and its intersection with the curves gives direct conversion between weight and atomic per cent.

To determine atomic percentages in the 80% molybdenum, 20% uranium alloy, the intersection of the R-line and 20% uranium is at point X. The curve for 9 at.% passes through this point. Expressed as atomic percentages, this alloy has 91% Mo, 9% U.

This chart may also be used if the atomic percentages are known and the weight percentages are wanted. For example, the alloy containing 50 at.% uranium and molybdenum is indicated by the intersection at point Y. The corresponding weight percentages are approximately 72% uranium and 28% molybdenum.

METAL PROGRESS DATA SHEET  
OCTOBER 1956; PAGE 96-B



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# Ultrasonic Shear Wave Testing

By W. J. McGONNAGLE\*

Ultrasonic flaw detection equipment may be used to inspect difficult-to-reach sections by using shear waves rather than the longitudinal waves normally employed. (S 13)

**E**LASTIC BODIES are capable of transmitting two types of ultrasonic waves, longitudinal and transverse or shear. In a longitudinal wave the particles of the transmitting medium vibrate to and fro in the direction of propagation of the wave. In a transverse wave the particles vibrate at right angles to the direction of propagation. The velocity of shear waves is approximately 50% that of longitudinal waves.

In testing plate or sheet with the longitudinal waves normally used, the source must be placed directly over a flaw before it becomes apparent. Ultrasonic shear waves, however, travel a zigzag path through the plate by successive reflections between the surfaces of the material, as shown in Fig. 1, until either an edge or discontinuity is reached. The reflected beam then returns to the transducer by a similar path. The pattern on the oscilloscope screen indicates the distance of the flaw from the transducer and the relative size of the reflecting area.

Shear waves will travel in a pipe by the path shown in Fig. 2 and have been used successfully for flaw detection in pipes. The technique used in testing pipe is to hold the transducer firmly against the pipe as the pipe is being rotated and slowly moved laterally. This assures complete coverage of the pipe and aids in interpreting the pattern on the oscilloscope screen. Since the pipe is moving, any flaws in the material have the

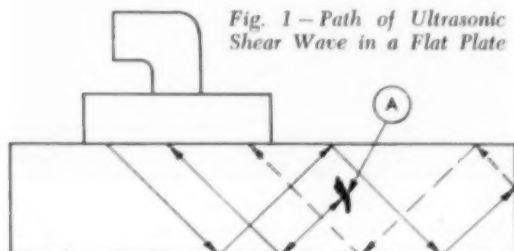


Fig. 1 — Path of Ultrasonic Shear Wave in a Flat Plate

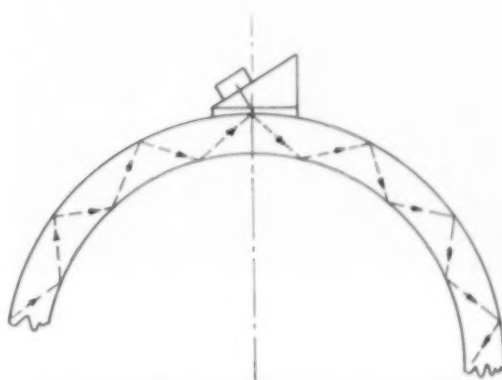


Fig. 2 — Shear Waves in a Round Pipe

same movement relative to the sound source; therefore, the flaw reflection is readily perceived on the screen by its movement to the right or left depending upon the direction of the pipe rotation. Any false or spurious indications remain fixed on the screen. Using this technique, it is possible to detect a shallow fold 1/64 in. deep in a 0.906-in. thick wall of a pipe or a fold 1/16 in. deep in a 1.125-in. wall.

The technique described above cannot be used on small tubing because of the blanking of the receiver at the instant of pulse transmission. The nondestructive testing group at Knolls Atomic Power Laboratory has developed a holder for testing small-diameter tubing with a gear arrangement for rotating the sample. The shear waves are made to travel parallel to the longitudinal axis of the tubing.

The transducer was modified by cutting 5/32 in. from the face of a commercial shear wave transducer. This was done to include a 1/4-in. plexiglas shoe with a groove (0.035 to 0.040-in. radius) along the diameter. The plexiglas shoe was made

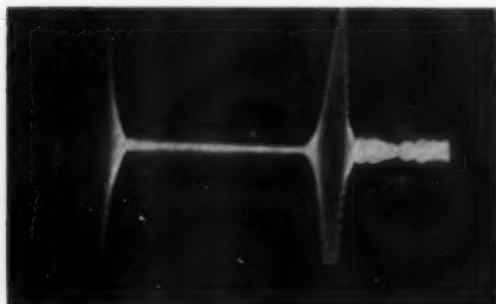
\*Associate Physicist, Metallurgy Div., Argonne National Laboratory, Lemont, Ill.

with a beveled edge on the outer surface opposite the side of the groove. The beveled edge limits the rotational orientation of the shoe with respect to the holder by coinciding with a bakelite tip protruding through the angular plexiglas wedge set in the housing. The shoe and wedge were coupled with a light oil. The plexiglas shoe could be made to rotate slightly either clockwise or counter-clockwise on the surface of the plexiglas

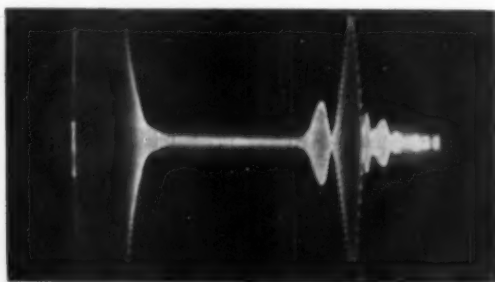
wedge. This permits orientation of the tubing with respect to the transducer for maximum transmission of sonic energy. If the plexiglas shoe were rotated to a point which exceeded the breaking point of the oil seal, poor transmission would result.

Different size tubing can be tested merely by interchanging shoes. The depth of the grooves in the plexiglas shoe should be slightly less than the diameter of the tubing to give a firm, direct contact with the tubing being tested and to facili-

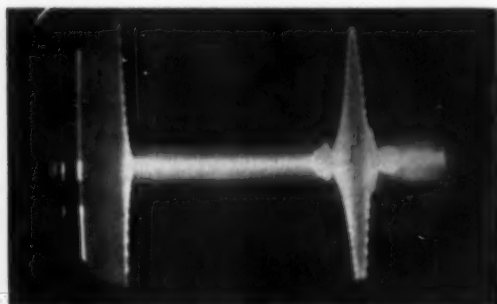
*Fig. 3 - Shear Wave Testing of Artificial Defects in Small-Diameter Tubing*



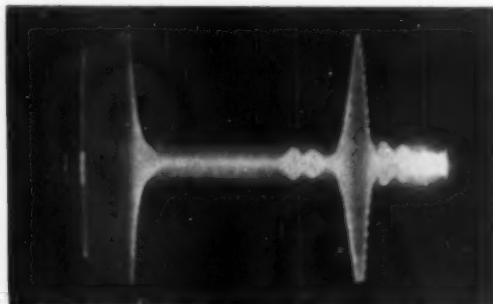
*Reflectogram of tubing shows no defects. Peaks are of initial pulse (left) and back reflection (right)*



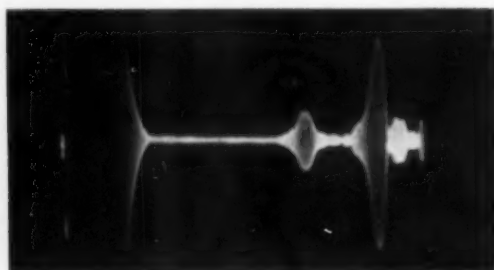
*File marking about 0.005 in. deep, 2 in. from end of tube and 40° circumferentially is indicated. Middle defect indication is 33% of back reflection*



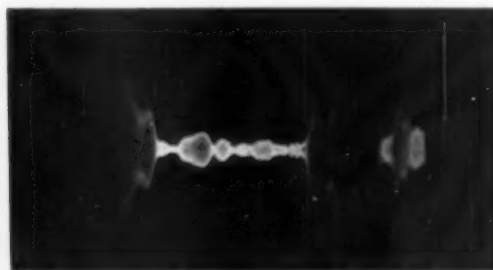
*Defect indication is that of notch 0.002 in. deep, 2 in. from end of tube, 1/32 in. wide and 180° circumferentially. Second indication from the left shows that the defect is 17% of back reflection*



*Two notches made circumferentially 3 and 4 in. from end of tube, 0.002 and 0.001 in. deep respectively, are indicated in reflectogram. Second and third indications show defects side by side*



*Single hole 4 in. from end of tubing through 0.010-in. wall (No. 80 drill). Second indication from left shows defect in 30% of back reflection*



*Axial groove in tubing is indicated by second largest peak from left. The groove is about 0.005 in. deep, 1/2 in. long and 2 in. from opposite end of tube*

tate good transmission of sound. By rotating the tubing with the transducer located at one end of the tubing, and moving a transducer longitudinally approximately  $\frac{1}{2}$  in., the length of a tube can be inspected.

The results obtained with various artificial defects using this technique are shown in Fig. 3. The initial pulse is the large indication at the left and the back reflection is the large indication at the right. The defect indication is between these two indications.

When examining small-diameter tubing, the echoes may tend to cover up some of the defects close to the transducer. This problem was solved by the use of a delayed shear wave search unit. In this search unit the transducer is mounted on a delaying wedge which delays the entrance of each pulse into the object by a time interval which is larger than half the duration of the pulse itself. To eliminate the reverberations due to reflections at the interface of the sample, an absorbing wedge is incorporated in the delayed shear wave unit. In this absorbing wedge both components of longitudinal and shear in the reflected beam are reflected back and forth along the walls, losing energy by absorption as they travel along. Using this type of shear wave unit, an artificial defect, a No. 60 hole  $\frac{1}{8}$  in. deep, was detected  $1/32$  in. below the surface.

A special shear wave unit has also been used for inspecting the bore of gun barrels. The shear wave is projected into the wall of the gun barrel and is reflected back and forth between the bore hole and the outer surface and circumferentially around the forging. Any discontinuity in the wall will reflect part of the beam back to the starting point. As the search unit is advanced to the bore, the entire body and the wall are inspected in a spiral manner as the tube rotates. Using this method, it is possible to detect cracks of very small area. The cross section of the tube varies as the transducer advances through the tube. It is necessary to compensate automatically for this change in length of the test beam path. This is done in discrete steps by the use of a counter system that is preset at the start of the test.

The shear wave technique can also be used for inspecting circumferential pipe welds. In this use, the shear wave is directed axially along the pipe. One major difficulty is the false indications or reflections that come from irregularities at the inner and outer weld surfaces. False indications do not affect the sensitivity of the test but do make interpretation of the results extremely difficult. It is often impossible to distinguish a reflection

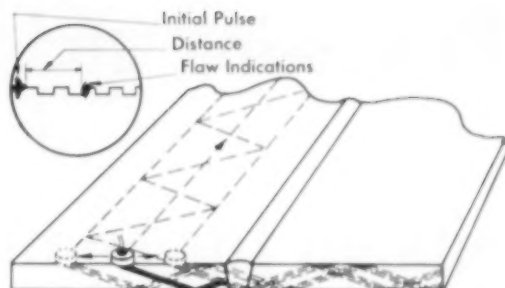


Fig. 4—Weld Inspection Using Shear Waves

caused by a surface irregularity from one caused by a flaw. This difficulty can be reduced by grinding the top and bottom surfaces flush with the bare metal.

As shown in Fig. 4, it is necessary to move the search unit back and forth while it is being moved parallel to the weld. It is also necessary to prepare the surface by removing any loose scale, rust or dirt on one side of the weld, approximately 6 in. from the weld.

Known defects such as slag inclusions, lack of penetration to the root and cold shuts were deliberately placed into a test weld and all were located by ultrasonic testing. Minor defects were found in some of the welds but in all instances the defects were smaller than that allowed by the A.S.M.E. code for piping defects when using radiography. After one year of operation, these welds were re-inspected and the same defects were located and were of the same magnitude.

Shear waves may be generated by use of a Y-cut quartz crystal. However, the method most widely employed for producing shear waves uses a source of longitudinal waves and a plastic wedge of the proper angle. The angle is determined by the same calculations used to design optical systems which depend on the difference in velocity of light waves in different mediums. The correct angle of the wedge makes it possible to reflect completely the longitudinal wave and have only the refracted shear wave enter the metal part. Due to shape and dimensions of the sample, the wave motion within it may sometimes be very complex and of more than one type.

Usually the shear wave transducer is placed in direct contact with the test object, but shear waves are also used in immersion testing. In immersion testing the transducer and test object are separated by a layer of oil or water. The shear waves are produced in the test object by mode conversion, since shear waves are not propagated in liquids.

# Processing and Purification of Silicon for Semiconductor Use

By D. K. HARTMAN and P. L. OSTAPKOVICH\*

The silicon used in electronic devices must contain less than one part in one hundred million of impurities, and techniques for obtaining such purity have now been developed. (Tl, Si)

**T**RANSISTORS and other devices made from germanium are limited in application yet have contributed so much to the miniaturization of electric equipment, both military and civilian, that interest has been stimulated in all other semiconductor materials which might offer greater utility. Gray tin, silicon, germanium combinations of these elements and combinations of elements in the third and fifth columns of the periodic table are semiconductors and can be used, but virtually all research effort in recent years has been concentrated on silicon.

Silicon was selected because of its availability, its excellent temperature characteristics (devices can operate above 390° F.) and also because of its favorable back-to-forward resistance ratio at room temperature. All of these factors have stimulated interest in silicon, particularly for the armed services.

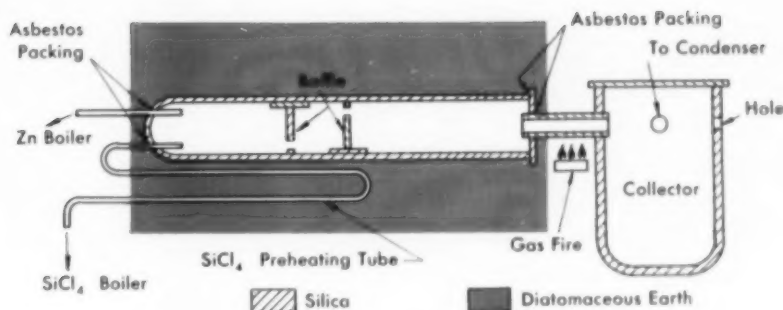
Silicon is not a new semiconductor; it was used in crystal mixers for radar receivers during World War II. However, the material used was polycrystalline and was guaranteed to have a purity of not less than 99.9%. Diodes, rectifiers and transistors manufactured from this material would be most unsatisfactory by present standards. Large single crystals of silicon with impurity

concentrations beyond spectroscopic analysis (> 99.999% pure) were produced in the General Electric Research Laboratory in 1952. Since that time, considerable effort has been directed toward purification, crystal growth, bulk parameter, heat treating, resonance and photoconductivity studies at the chemical and physical research levels as well as engineering laboratory levels to understand the processing and purification of silicon. Now a quality of silicon has been perfected that is suitable for most diodes, rectifiers and transistors.

Silicon is the most abundant solid element found on the earth's crust. It is very active chemically and is never found in a free state. Because of its affinity for other elements, purification of silicon has been more difficult than of germanium. Silicon melts at 2610° F. compared with 1760° F. for germanium and this also has made the processing more difficult. High-purity carbon crucibles are suitable for germanium but will not work with silicon because the silicon reacts to form silicon carbide. Other high-temperature crucible materials such as alumina, zirconium, molybdenum and tantalum are unsatisfactory because of chemical reaction or cost. Accordingly, fused natural quartz has been selected as the best commercially available material.

Silicon is found in the fourth column of the periodic chart with an atomic number of 14 and an atomic weight of 28.06. In the pure crystalline state it has a diamond cubic structure like germanium and gray tin. The lattice constant

\*Semiconductor Products Dept., General Electric Co., Syracuse, N.Y. Based on work supported by the U.S. Air Force Air Research and Development Command and the U.S. Air Force Air Materiel Command under contracts AF 33(600)-17793 and AF 33(600)-28956.



*Reactor Chamber Used to Prepare High-Purity Silicon*

for silicon is  $5.42\text{\AA}$  and its density at room temperature is  $2.33\text{ g. per cc.}$  It has a definite nonmetallic luster and is characterized by its blue-gray color.

For silicon to be of value as a material in high-quality semiconductor devices, it must contain less than one foreign atom for every  $10^8$  atoms of silicon. The most common process for chemically purifying silicon has been the reduction of silicon tetrachloride with zinc. The reaction takes place at  $1740^\circ\text{F.}$ , well below the melting point of silicon but well above the boiling point of zinc, zinc chloride and silicon tetrachloride. The zinc chloride formed in the reaction and any excess zinc or silicon tetrachloride are carried off as vapor. The silicon is deposited on the bottom of a reactor chamber in the form of needle-shaped crystals.

Two forms of silicon have been commercially available for processing into large single crystals—the small needle crystalline structure and a densified form. The latter is prepared by melting a large pot of needle silicon, allowing it to cool and then fracturing it. The densified material has the advantage that dross and volatile material are removed at the high melting temperature of silicon, thus facilitating crystal growth. At General Electric the needle silicon is initially melted and cast in the form of a long cylindrical ingot, approximately  $\frac{3}{4}$  in. in diameter and from 12 to 14 in. long. The billet derived from this "pre-melt" operation is then zone refined. Zone refining is the method by which further purification of silicon is obtained through the segregation and removal of impurities from the front end to the tail end of the billet.

The Bell Telephone Laboratories developed the technique of zone refining for purification of germanium, and this process is essential to produce the best germanium. General Electric Research Laboratory perfected zone refining of

silicon, and zone-refined silicon is necessary to produce the best single crystals as indicated by resistivity and lifetime measurements.

Following the zone purification, the silicon is suitable for processing in the single-crystal silicon furnaces. With proper thermal and mechanical furnace design and with adequate temperature control, single crystals of silicon are grown in a reproducible fashion. Using the cleanest inert atmosphere possible, molten silicon is removed from a fused quartz crucible in a manner patterned after the Czochralski principle. The silicon that has been purified to the highest degree possible is then purposely contaminated with impurities of known amounts. These impurities are the donor-acceptor elements found in the group V or group III elements, respectively, of the periodic chart. If p-type conductivity is required by the device area, the silicon is doped with one of the group III elements. If n-type conductivity is required, then one of the group V elements is used. The addition of impurity atoms is a very precise technique requiring the addition of one impurity atom for every 10,000,000 silicon atoms. That is equivalent to diluting 2000 lb. of pure silicon with 0.0003 oz. of an impurity such as arsenic or antimony.

The silicon is doped while at a temperature in excess of  $2600^\circ\text{F.}$  Because of the high temperature, it is not easy to retain the impurity atoms in the molten material since some of the donor-acceptor elements tend to boil off during the processing and growth of single crystals. Controlled doping of silicon thus becomes a major task. Extreme cleanliness, patience and control have yielded the best single crystals of silicon as judged by bulk measurements.

Single-crystal material represents an organized geometric array of atoms. This geometric array or pattern is reproduced time and time again with minimum faults or distortions so that prop-

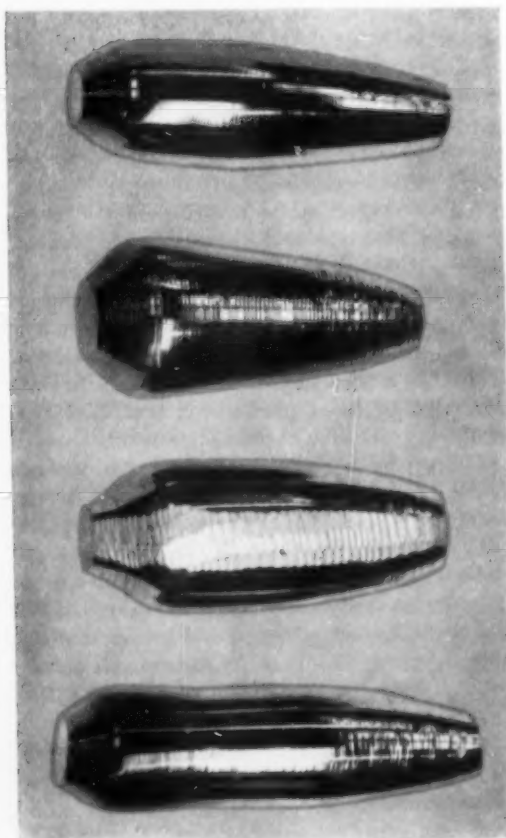


*Billets of Silicon Formed in Premelt Furnace*



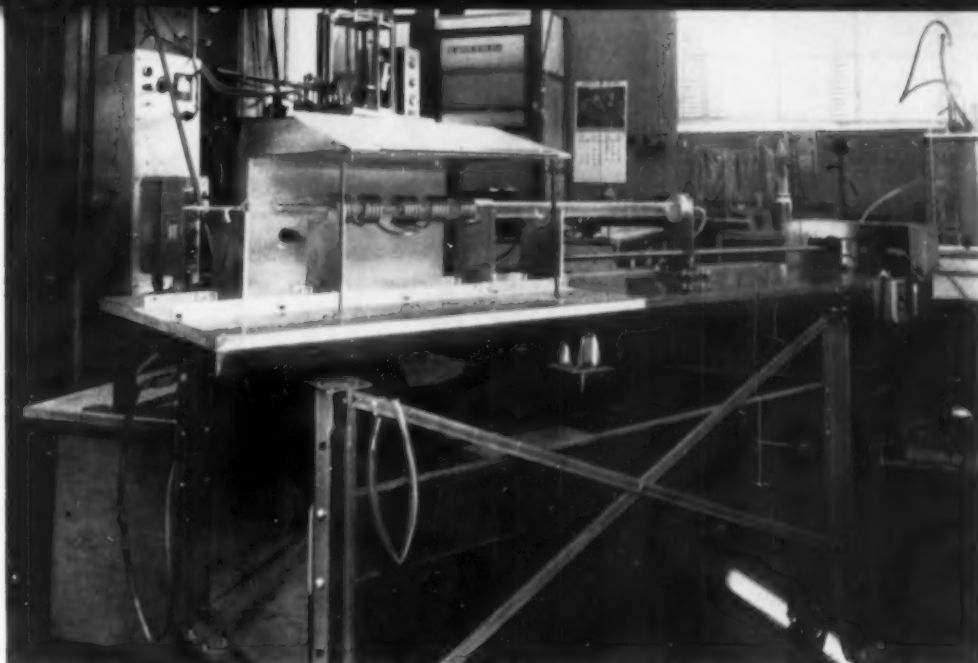
*Zone-Refined Silicon Ingots*

*Single Crystals of Silicon*



erties of electronic components made with such material are uniform. In addition, the total yield from the single crystal is greatly increased with a homogeneous material. In polycrystalline material and in most metals, the atoms are arranged unsystematically like a pile of bricks having no pattern, no organization, and no beauty in the structure. In contrast, a single crystal is like a brick wall. It has a precise pattern and an organized structure; depending upon the ability of the mason, it has beauty and perfection. This same beauty and perfection can be found in a single-crystal material but depend upon the ability of the engineer to produce and control conditions under which very nearly perfect crystals will grow.

Silicon as a semiconductor material is characterized by a band gap of 1.11 ev. at room temperature that decreases linearly as the temperature increases. Moreover, the charge carrier concentration in silicon is temperature dependent. This implies that silicon devices are temperature sensitive; the percent change over a given range will be greater than germanium and at room temperature silicon has a much smaller saturation current than germanium. It should operate as a semiconductor at a junction temperature of 390° F. It should also have a higher forward impedance than germanium devices and a much higher back impedance. Because silicon starts at a much lower value of saturation current



*Equipment Used for Zone Refining of Silicon*

at room temperature, silicon devices have much better temperature response in spite of the greater change in saturation current for an equivalent change in temperature.

General Electric has set as its goal the manufacture of semiconductor devices including diodes, rectifiers and transistors that are capable of operating at an ambient temperature of 390° F. Such devices must have long life, must be stable and must have characteristics useful at this temperature. Stability infers that the devices must operate at high temperatures and high humidity and survive rugged mechanical shock tests. This operation must be consistent for a long period of time with no failures so as to assure the armed services and the electronic industry of reliable products.

Two difficulties have deterred the rapid progress of silicon for commercial products. One deals directly with the temperature stability of silicon; the second pertains to the generation of a high-lifetime silicon and the retention of this lifetime during processing. Lifetime as discussed here is a measure of perfection in silicon crystals. It is not how long the crystal or the semiconductor device will last but is the length of time that an excess of minority carriers purposely injected takes to disappear. Until a few months ago, lifetime of the best silicon was a few ten-thousandths of a second. Now, lifetime is in excess of a thousandth of a second. This is not long by the clock, but to conduction electrons or holes it is practically forever.

Early in the research stages of silicon purifi-

cation, it was found that silicon was thermally unstable at 840° F. P-type material when held at that temperature for a considerable period will change resistivity and even type. If n-type material is held at this temperature for a considerable period of time, the bulk resistivity of the material degrades seriously. This change in resistivity alters the saturation current characteristics of a silicon device and also lowers its effective operating voltage. Furthermore, p-type devices are subject to a complete reversal of conductivity which would render the semiconductor product useless. As a specific example, a p-type crystal which started out with a bulk resistivity of 250 ohm-cm. was heated for 16 hr. at 890° F. and changed to n-type material with a resistivity of 0.35 ohm-cm. It has been found that the thermal conversion of silicon is minimized if crystals of silicon are grown without rotation and if thermal shocks are avoided during the growth cycle.

Bulk lifetime measurements are significant and useful in that they are a measure of crystal perfection and level of impurity concentration. The lifetime affects the saturation current of a diode or rectifier. With too short a bulk lifetime, the minority carriers would be unable to drift from the emitter to the collector in a transistor and it would be of little commercial use. With bulk measurements revealing resistivities in the range of 200 ohm-cm. and lifetime in excess of 0.001 sec. for n-type material, it is adjudged that silicon of sufficient quality can now be mass produced for reliable semiconductor devices. ☉

# Automatic Submerged-Arc Welding of Alloy Steel

By R. A. WILSON\*

Welds with properties that match those of the parent alloy steel can be made by the submerged-arc process with mild steel wire and special fluxes which supply the alloying elements required. (K1, AY)

**T**HE INCREASED USE of low-alloy high-strength steels in welded structures has introduced a serious production problem in many fabrication plants. Conventionally, manual welding is used for such steels but in big weldments, such as are used in pressure vessels, earth-moving machinery and power plant equipment, it is too slow and the weld quality may not be as uniform as that obtained with automatic equipment.

When carbon steel is used for equipment made from heavy plate in which long, continuous multipass welds are required, it is welded by the submerged-arc process with automatic or semi-automatic equipment. The welding wire is mild steel and a neutral flux is deposited continuously over the arc as it traverses the joint. Such welds have properties that match those of the carbon steel plate but would not be strong enough in an alloy steel weldment.

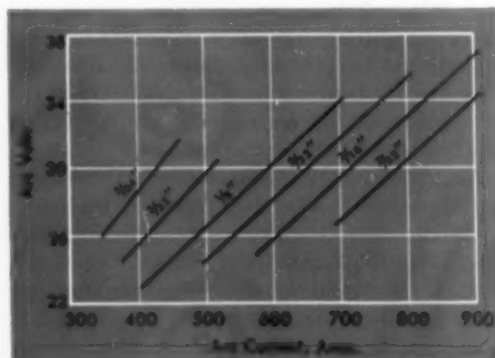
Manual welding with coated electrodes has been required to obtain strength in the weld equal to that of the alloy steel being welded. The alloying elements necessary are obtained by using either a suitable alloy core wire or alloys in the flux coating. For submerged-arc welding, the range of wire compositions available is limited and the neutral flux used adds nothing to the weld.

Even if a sufficient variety of alloy wire compositions were available, the fabricating shop would find it a difficult task always to have on hand enough wire of the right size and composition for the job. Furthermore, good welding

practice occasionally requires the weld composition to be different from that of the plate. The problem would go all the way back to the steel mill which might have to process special heats just for a particular type of welding wire—a costly procedure at best.

One solution is a new series of alloy fluxes for automatic welding which permits the introduction of desired alloy content to the deposit of mild steel. This of course is the same thing that is done in manual welding by providing alloy in the welding rod coating, except that in automatic welding the flux is an agglomerated granular material which flows over the arc continuously and is fused into a molten covering for the weld crater, then solidifies to form a thin slag crust on the weld bead which peels off

Fig. 1—Arc Voltage and Current Recommended for Single-Pass Submerged-Arc Welds. Mild steel electrode. Polarity: d-c electrode positive



\*Director, Application Engineering, Lincoln Electric Co., Cleveland.

readily to leave a bright smooth deposit. The action might be likened to that of a miniature traveling electric arc furnace, with the welding wire furnishing the mild steel "bath" and the flux supplying alloy additions and slag covering.

Alloy fluxes, as now used, are actually mixtures of two or more of five primary fluxes, four of which contain one principal alloy element each, the fifth being a neutral type. The four elements are chromium, molybdenum, vanadium and nickel. Each primary flux is made by agglomerating its alloy with fluxing materials.

Briefly, agglomeration involves mixing the properly formulated, finely ground ingredients and flux particles together with a proper binder, and drying or sintering the resultant agglomerate. This is then ground to the desired size for submerged-arc welding. Each particle or grain of this agglomerate flux contains hundreds of the finely ground particles held together with a binder. Each grain contains the preprocessed minerals and deoxidizers in correct proportion.

Ground particles are screened to the same range of sizes; all have the same physical shape, and they are all very nearly the same specific gravity so that, after blending, there is no segregation. Any combination of the primary fluxes can be prepared to make an alloy flux tailored to a specific automatic welding application; possible combinations are literally infinite. The maximum alloy deposit recommended for each element is 7% for chromium, 4% for molybdenum, 1.5% for vanadium and 7% for nickel. These ranges include the compositions of most low-alloy steels; if more of any element is required, it can be supplied by using an alloy wire.

To maintain a consistent weld deposit composition, there must be a consistent ratio between the flux melted and the electrode melted. Manual welding electrodes inherently maintain this ratio since the amount of coating melted is proportional to the amount of core wire consumed. In submerged-arc welding, this ratio must be controlled by welding procedure; that is, electrode wire diameter, arc volts and arc current.

By standardizing on procedures, it is possible to reduce the number of flux compositions which might conceivably be required. Values of arc voltage and current recommended for single-pass welds with various wire sizes are summarized in




Plate	Electrode	Amp.	Volts	Speed in. per Min.
	(1) $\frac{1}{8}$ "	550	27	24
	(2) $\frac{3}{16}$ "	630	30	24
	(1) $\frac{1}{8}$ "	550	27	20
	(2) $\frac{3}{16}$ "	700	32	16
	(1) $\frac{1}{8}$ "	700	30	22
	(2) $\frac{3}{16}$ "	850	35	16

Fig. 2—Welding Procedure for Butt Welds in Plate of Various Thicknesses

Fig. 1. Their specific application to butt joints in three thicknesses of plate is shown in Fig. 2.

Each application of alloy steel weldments must be analyzed to determine the best weld metal composition to meet service requirements. Chromium-molybdenum steels for elevated-temperature operation constitute one example. They include a large number of compositions increasing in alloy content as temperature or operating stresses rise. Chromium from 0.5% to 5% is added to the weld metal, principally for its effect on resistance to oxidation and corrosion but it also contributes in some degree to creep resistance. Chromium is also added to the plate steel as insurance against graphitization in high-temperature service but this has not been a problem in weld metal. Molybdenum is added, usually from 0.5% to 1%, for its effect on resistance to creep. Occasionally, vanadium is added for the same purpose.

Some chromium-molybdenum steels contain high silicon to increase resistance to oxidation. Such alloys are welded with standard compositions of chromium-molybdenum fluxes and the chromium content is increased to compensate for the lower silicon content in the weld.

Carbon normally is limited to a maximum of 0.20% with lower limits for the higher alloy steels. High carbon can cause cracks during welding so welds made with alloy fluxes and low-carbon wire will rarely have more than 0.10% carbon.

Composition of Multipass Butt Weld in 3-In. Alloy Steel Plate

	C	Mn	Si	Cr	Mo
Plate	0.20	0.55	0.50	0.55	1.0
Weld metal—top	0.18	0.73	0.42	1.15	1.05
Weld metal—center	0.16	0.73	0.43	1.15	0.94
Weld metal—bottom	0.17	0.74	0.42	1.12	0.90



*Fig. 3—Semi-Automatic Welding of a Dipper Stick Made of T-1 Steel*

Manganese content is sometimes limited to a maximum of 0.60% in chromium-molybdenum steel plate but more manganese is desirable in the weld metal from the standpoint of improved physical properties and resistance to cracking. The composition of a butt weld in a 3-in. alloy steel plate is shown in the table on the preceding page to indicate how weld metal may differ in composition from the plate and how consistent the weld metal composition may be maintained with alloy fluxes.

Another classification of alloy steels includes those which are heat treated before welding and are placed in service as welded or after stress-relieving. The complex low-alloy T-1 steel developed by U. S. Steel Corp. is in this group. To match the properties of T-1 plate, weld metal must have a minimum yield strength of 90,000 psi. and minimum tensile of 105,000 psi. and must also have good impact properties at low temperatures, both as-welded and stress-relieved. The

weld metal is alloyed to meet these requirements rather than to duplicate the involved plate chemistry.

Best welding practice calls for less than 0.10% carbon in the weld metal, and therefore sufficient alloy must be added from the flux to meet the required yield and tensile strengths. Chromium, molybdenum and nickel are added to meet impact, yield and tensile strength requirements. The composition of the weld metal in T-1 steel is approximately 0.08% C, 2% Ni, 1.3% Cr, 0.9% Mn, 0.6% Mo and 0.4% Si. The composition of the steel is 0.15% C, 0.9% Ni, 0.5% Cr, 1.0% Mn, 0.6% Mo, 0.25% Si, 0.35% Cu, 0.05% V and 0.004% B.

Transition temperatures are  $-175^{\circ}$  F. for as-welded specimens and  $-125^{\circ}$  F. for stress-relieved specimens. Room-temperature impact strength is 20 to 27 ft-lb. as-welded or stress-relieved.

An example of the application of alloy flux to the automatic welding of T-1 steel is a 65-ft. dipper stick recently made for a 35-cu. yd. shovel for use in strip mining. Rectangular in cross section,  $13\frac{1}{2} \times 25$  in., the stick is made up of 20-ft. lengths of plate, 2 in. thick on the bottom and 1½ in. on top, with side panels 1½ in.

Before welding the plates, a  $45^{\circ}$  bevel with no land was cut on the 1½-in. plates which were fitted flush between the top and bottom plates to form a deep V-groove. The 20-ft. plates also were beveled  $45^{\circ}$  at the ends before being joined to make the full 64½-ft. lengths. These plates were cut on a  $20^{\circ}$  bias and the joints were staggered. Before welding, the plates were preheated to  $300^{\circ}$  F.

Submerged-arc welding was accomplished with a self-propelled buggy carrying the wire nozzle and flux cone which traveled at 4 to 5 in. per min. along the length of the joint. The buggy was guided by wheels mounted on a channel-iron rail welded to the plate on the far side from the joint, as shown in Fig. 3. The technique is known as semi-automatic or "squirt" welding.

Six passes were required along the length of the stick to fill each groove, a total of 520 ft. of 1½-in. deep groove weld, or a total travel by the buggy of 3120 ft. The piece was rotated after each pass to distribute heat evenly as a precaution against distortion. Turning was accomplished easily by locating the stick in two large wheels of 1½-in. plate, cut out sufficiently in the center to accommodate the section. These wheels turned on two track rollers firmly fastened to the floor. To permit uninterrupted passage of the welding

"gun" at points where the stick passed through the turning wheels, the tops of the latter were burned off and then welded back on after the pass was completed.

On the first pass, a 30° angle was set on the welding wire to give 100% penetration through to 1-in. square mild steel backing bars located on the inside at each corner for the full length. These backing bars aid in obtaining full weld penetration on the first pass. Welding wire, fed into the flux cone automatically, was 5/64-in. mild steel, supplied in 60-lb. coils. A stringer

bead procedure was used. The finished stick was stress-relieved at 1100° F.

Preliminary estimate of welding time for manual welding a stick of this size was 760 hr. By using submerged-arc welding with the setup described, the time was cut to 197 hr.

Similar savings in production time can be realized in many plants where manual welding of alloy steels has previously been necessary. In addition, the automatic control of welding conditions produces more consistent weld composition and properties. ☼



## Use of Oxygen in Steelmaking

By E. C. WRIGHT\*

OXYGEN IN IRON AND STEEL MAKING, by J. A. Charles, W. J. B. Chater and J. L. Harrison, Butterworth Scientific Publishers, London, 1956, 316 p., 42 s. Interscience Publishers, Inc., New York, 1956, \$6.50.

This timely volume gives an exhaustive summary of the literature on the subject through 1955. The book is subdivided into three sections, namely, the treatment of molten metal with oxygen, blast enrichment with oxygen in solid fuel combustion, and flame enrichment.

Each section is headed with a chapter on the physical and thermochemical effects of oxygen in these particular applications, and includes many useful calculations as to the influence of oxygen on the energy balance, temperature increase, reaction rate and oxygen efficiency of the processes involved.

The first seven chapters, dealing with the treatment of molten metal with oxygen, are thorough and give the reader a good perspective of these developments throughout the world. The

chapters on desiliconizing of hot metal, converter practice and applications in the openhearth and electric furnace are particularly good. The great benefit to openhearth production from desiliconizing is demonstrated by reports from many sources. The review of the great advantage of oxygen blowing on stainless steel melts in electric furnaces is especially good; in this melting process, the use of oxygen permits the melting of stainless scrap, and the resultant increase in production has been one of the most important uses of oxygen.

The oxygen converter has solved one of the oldest steelmaking problems on the European continent. The preponderant use of the bottom-blown basic converter on the continent has limited the use of such steel because of its normal high nitrogen content (0.012 to 0.018%). The oxygen converter produces steel low in nitrogen which has been found to be equal to openhearth steel for most cold forming operations. This new process seems to be limited to pig irons containing less than 0.50% phosphorus but it is being used in two American plants and three more American installations are being built.

\*Head, Department of Metallurgical Engineering, University of Alabama, University, Ala.; Consulting Editor, *Metal Progress*.

The high-phosphorus pig irons so common in the French, Belgian and Luxembourg steel plants have not been refined as yet by the oxygen-blowing process, and engineers in these plants have solved the high-nitrogen problem by blowing high-phosphorus pig irons with oxygen-enriched air with additions of cold scrap, iron ore, roll scale and raw limestone instead of burnt lime. As a result, the use of a blast containing 30% oxygen has produced steel with nitrogen under 0.005% in the bottom-blown basic converters from these high-phosphorus pig irons. The oxygen consumption in this process averages 790 cu.ft. per ton of steel and costs about 50¢ per ton. Experiments in Germany in top-blowing 2% phosphorus irons with oxygen have been successful in producing low-nitrogen low-phosphorus steels when large cooling additions of iron ore or roll scale ranging from 100 to 280 lb. per ton are made.

The author points out the essential difference between the L-D process and the old Thomas process. In the L-D process, large additions of cold scrap combined with a highly oxidizing slag keep the bath temperature low in the early stages of the blow, and much of the phosphorus is eliminated before the carbon reacts. The reverse

action occurs in the bottom-blown Thomas process where carbon oxidizes before the phosphorus so that an afterblow is necessary.

The author also emphasizes the lower operating cost per ton of steel of the L-D process, its greater production rate and the much lower capital cost for plants of equivalent output. The apathy shown by English steelmakers to this process is amazing. The economic advantages of the L-D process are tremendous.

The use of oxygen in openhearth for increasing melting rate, decarburizing and refining is thoroughly reviewed. Here the results are not nearly as spectacular as in the converter but some definite economic advantages are present. Much of this work has been of an experimental nature using high-cost oxygen so that the economic discussion is somewhat clouded.

No mention is made of the spectacular use of oxygen in the flash smelting of sulphide ores, probably due to the lack of publications on this subject. The book is also disappointing in that it gives no figures on the cost of producing oxygen of different grades of purity. The technical advantages of oxygen in smelting are many but the cost is still highly debatable; wider use will largely depend on this factor. ☉



## Hush, Hush!

**I**N A RAPID TRIP down the Front Range of the Rockies, during the spring, was shown about by Dan Murphy at Los Alamos and Bob Townsend at Sandia-Albuquerque, and talked informally to the ☉ Chapters in both these New Mexico cities about national society affairs and plagiarized Al Boegehold's talk about what the automobile engine will look like 10 years hence, and went out on a limb all of my own in venturing the opinion that we may then resurrect the old electrics for use as the urban family's second

car—it being small and parkable, unattractive to the hot-rodding teen-agers, and uses no expensive gasoline. During these days I had the privilege of seeing many things behind the high Cyclone fences and a few of these may be passed on as containing no "classified" information.

Los Alamos, it will be recalled, is the place where the wartime atom bombs were put together from uranium-235 separated at Oak Ridge and plutonium made at Hanford. Since the beginning it has been operated under contract by the University of California. When Oppenheimer and his group moved into this place early in



1943 it was a small, isolated boarding school for boys and they thought about 100 men would be required. By the end of the war many times that many scientists, engineers and technicians were on the site. Since then practically the whole place has been rebuilt into a delightful residential community and a group of laboratories widely scattered over the wooded mesas. The individual laboratories are most excellently equipped with every necessary facility. For example, an entire building is given over to nondestructive testing; so much radiographic inspection is done that the whole operation through to the examination of films is practically automatic, and even robot scanning may eventually be practicable. An extensive laboratory studying the man-made metal plutonium is put between an enormous blowing and air conditioning plant and an oversized bag house for air filter. Plutonium is really poisonous; fortunately it decays by emitting alpha particles (helium nuclei) which are so large and travel so slowly they cannot get through glass or rubber gloves, so nearly all the work goes on in hoods ("dryboxes") with conventional equipment—except that the metal is so active, chemically, that all operations at even moderately elevated temperature require a vacuum or an argon atmosphere. You never saw so much vacuum equipment in your life!

OCTOBER 1956

Cyril Smith, who with J. W. Kennedy headed the Chemistry and Metallurgy Division at Los Alamos during wartime, wrote for *Metal Progress*, May 1954, a fascinating account of the work done there. That article summarizes about all the information about the metallurgy of plutonium as is in the open literature, and it also tells about the part played by Eric Jette (still in Los Alamos and now in general charge of the metallurgical work) and by Jim Taub (who presides over one of the wartime wooden buildings still standing with its great collection of life-sized fabricating machinery capable of doing about anything you could wish to any metal or alloy, no matter how expensive, radioactive, or outlandish.)

Sandia Corp. is operated by Western Electric Co., under contract with U.S. Atomic Energy Commission to study what is officially described as "ordnance engineering of weapons". That phrase is about as vague as the Editor's understanding of the electronic devices which seem to be the building blocks of the extraordinary control and recording systems which appear on all sides.

Here also is an almost unique example of cooperation; the Army, Navy and Air Force feed in ideas and specifications and extract prototype weapons. At Sandia, again, the air conditioned buildings contain an impressive array of instrumental equipment; most of the field tests are made in devices locally designed and built. The common characteristic of the work is "extreme conditions". Acceleration tests can be made on subassemblies at 200 times gravity. Exposure tests can duplicate any condition from sandy desert to humid tropics at sea level, and to stratospheric conditions 20 miles up. They require electronic transmission and registration of data; the instrument design, construction and calibration section at Sandia is consequently most highly developed.

All these, and many other studies, are intended to determine the effect of extreme environmental conditions on weapons as they encounter high temperatures, high temperature gradients, extraordinary accelerations, velocities and vibrations—all new to peacetime engineering. It is a sad reflection that so many brilliant men and so much expensive equipment is required to perfect weapons for the next war, which, pray God, will never come. But after just one day at Sandia, the Editor cannot get excited about the supposed "superiority" or "leadership" of the Russians in this field of endeavor.

# Power Reactors for the Military

**N**AVAL REACTORS PROGRAM is aimed at developing and evaluating power plants to propel many sizes of naval ships from small submarines to the largest aircraft carriers.

The land prototype of the U.S.S. Nautilus propulsion plant at the National Reactor Station in Idaho is being converted into a testing facility where technology, design, and operation of improved water-cooled nuclear power plants will be investigated, and improved design cores can be tested. Modifications include a new steam generator heated by the primary coolant, and changes so as to operate at higher powers and temperatures. The reactor core and fuel were renewed after 30 months of operation and testing.

The U.S.S. Nautilus now has operated for a year and a half.

Operation of the land prototype of a nuclear propulsion plant for the submarine Seawolf continued at West Milton, N.Y. for the training of naval personnel. The U.S.S. Seawolf neared completion at Electric Boat Div., General Dynamics Corp., in Groton, Conn. A contract for the sale of excess electric power generated in the prototype plant at 3 mills per kw-hr. became inoperative because the two municipalities had been unable to make arrangements to transmit the power into the municipal systems.

Congress authorized the construction of a nuclear-powered radar picket submarine in the Navy's ship-building program for fiscal year 1956. This submarine, to be powered by two S3G-type nuclear reactors, will be the largest submarine ever built, and the first powered by two reactors. The prototype S3G is being designed at Knolls Atomic Power Laboratory, Schenectady, N.Y., and construction of test site and facilities has begun.

Design of a nuclear propulsion plant for a small submarine has been undertaken by contract with Combustion Engineering, Inc., of New York City. This third major contractor to enter the naval reactor development program will carry out the work in facilities being constructed near Windsor, Conn.

Design and development of the Large Ship Reactor prototype propulsion plant at Westinghouse Electric Corp. continued at the Bettis Plant in Pittsburgh. Construction of test site facilities began in April. Knolls Laboratory is to design an organic reactor of small size and weight intended to power a light naval vessel. The experiment is to provide information on the use of organic compounds as coolants for naval reactors.

**Army Reactors Program** includes three major projects. Construction of the Army Package Power

Reactor (APPR-1) continued at Fort Belvoir, Va., under supervision of Alco Products, Inc. Scheduled for operation early in 1957, it is intended to produce 1825 kw. of electricity. Auxiliary work on pressurized-water systems for military reactors was done at Oak Ridge and at Columbia University. Fuel element projects are under contract with Nuclear Development Corp. of America and Sylvania Electric Products, Inc.

Argonne Low Power Reactor (ALPR), a project established in November 1955, calls for a boiling water, heterogeneous reactor for military use. The net power output would be 200 kw., about 10% that of the APPR-1. Experiments on materials and control systems for military reactors continued at Argonne and at Battelle Memorial Institute.

The Food Irradiation Reactor (FIR) is a project for the Army Quartermaster Corps. Experiments were continued to demonstrate whether foods sterilized by this process would be nontoxic, acceptable to consumers, adaptable to efficient handling techniques, and economically competitive with foods preserved by other processes. It was concluded that such a reactor should be optimized for gamma-ray production. Various designs are now under study.

In addition to the above three projects some interesting work has been done on elements of a small power plant where the gas is used as the main heat transfer system. Other work along this line contemplates the use of the hot gas directly in a gas turbine.

**Aircraft Reactor Program** of research and development progressed satisfactorily in close coordination with the Air Force, the Navy Bureau of Aeronautics, and the National Advisory Committee for Aeronautics.

The previous semi-annual report mentioned that the program had been accelerated and "prospects for nuclear-powered flight continued to show promise". The Aircraft Nuclear Propulsion Dept. of General Electric Co. is the operating contractor; much of the work is concentrated at Lockland, near Cincinnati. Contracts had already been let for the design of the airframe, and a new plant was being built by Pratt & Whitney Aircraft Div. at Middletown, Conn., "to enable that firm to enter more extensively into the programs" of the A.E.C. and the Air Forces.

A new test building, a shielded control and equipment building, and supporting facilities are to be built at the National Reactor Testing Station in Idaho, costing about \$12,000,000. Design work is expected to take ten months and construction to start in the spring of 1957.

Contracts have also been let for the design of a runway and auxiliary facilities to be constructed at the testing station.

\*Verbatim extracts from 20th Semi-Annual Report of the Atomic Energy Commission to the Congress of the United States.

for steel or non-ferrous metals

## FIVE SPECIAL TITANIUM ALLOYS

Whatever your low-carbon titanium requirement, there's an ELECTROMET titanium alloy to suit your melting practice. ELECTROMET produces three standard grades of low-carbon ferrotitanium, each grade containing a maximum of 0.10 per cent carbon. Of special interest to producers of high-quality forgings are the low aluminum and silicon contents of this alloy, which make ELECTROMET ferrotitanium specially suited for the production of forgings having good mechanical properties.



### ANALYSIS OF "ELECTROMET" LOW-CARBON FERROTITANIUM

Element	30% Titanium Grade	50% Titanium Grade	70% Titanium Grade
Titanium	27.32%	50.55%	68.72%
Aluminum	0.15% max.	0.15% max.	0.15% max.
Silicon	0.10% max.	0.10% max.	0.10% max.
Carbon	0.10% max.	0.10% max.	0.10% max.
Size	2 in. x Down	2 in. x Down	2 in. x Down

### OTHER TITANIUM ALLOYS

Silicon-Titanium		Manganese-Nickel-Titanium	
Titanium	40-50%	Titanium	46.5-48.5%
Silicon	45-50%	Manganese	6.8%
Iron	3.00% max.	Nickel	29-31%
		Aluminum	12.5-14.5%
Sizes: 2 in. x Down, 1 in. x Down, 20 Mesh x Down		Size: 2 in. x Down	

ELECTROMET also produces a silicon-titanium and a manganese-nickel-titanium alloy. Silicon-titanium is available for adding titanium to either non-ferrous alloys or steels where the simultaneous addition of silicon is desired. Manganese-nickel-titanium is available for adding titanium to nickel-base high-temperature alloys.

For additional information about ELECTROMET titanium alloys, please contact the nearest ELECTROMET office listed below.



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## Correspondence...

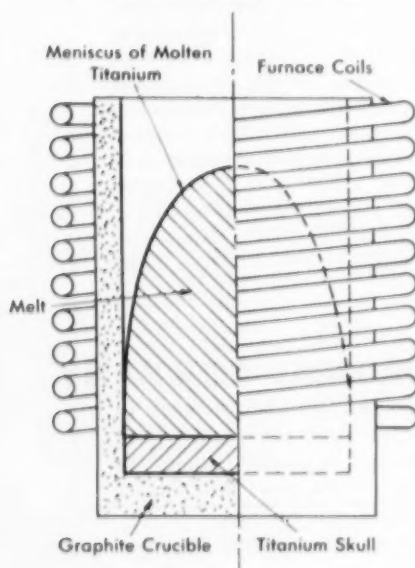
### Induction Melting of Titanium

WATERTOWN, MASS.

We believe that we, at Gen. Thomas J. Rodman Laboratory of Watertown Arsenal, are on the track of an improved method for melting titanium sponge (and scrap) and our work has progressed far enough for a preliminary report. We are using a small induction furnace and graphite crucible and have been able to minimize the carbon pickup principally by limiting the time the metal is molten and limiting the area of contact between crucible and melt.

We use a crucible machined from "CS" grade graphite and put energy into the furnace at a very rapid rate.

*Idealized Cross Section of Titanium Melt Under Influence of Strong Electrical Field in Induction Melting Furnace*



Furthermore, we put a solid titanium skull in the bottom of the crucible by melting a small button of metal and letting it freeze. We arrange the electrical coils so that this skull gets a minimum of energy, as shown in the sketch. About 5 lb. of titanium sponge briquettes or scrap was charged, the furnace chamber evacuated and refilled with helium, and power turned on (65 kw.). The metal promptly melts, and since it has low density and the electrical currents stir or swirl it vigorously, a very steep meniscus is maintained, out of contact with the crucible walls except at the very bottom. The contents are then lip-poured into a graphite mold. The metal is molten only one or two minutes.

In judging the experimental results, carbon pickup was considered most significant. Carbon in the sponge was 0.025%; carbon in the 4.5-lb. ingot melted under optimum conditions was 0.066%; others analyzed 0.11 to 0.15%—considerably below the minimum reported in the literature for melting in graphite by any process. Carbon in the all-scrap melts of 6% Al, 4% V alloy was 0.046%, and this rose to only 0.157% in the best heat.

Physical properties of forged bars from these small melts were good. In fact, results were so encouraging that the equipment has been modified so that 25-lb. melts can be made. The first melts in this new experimental program show a more consistent value for carbon pickup. We plan on presenting data on physical properties of the product as soon as the program is completed and the results analyzed.

PAUL J. AHERN  
CONRAD F. FREY  
Rodman Laboratory  
Watertown Arsenal

### Modification of Al-Si Casting Alloy

BIRMINGHAM, ENGLAND

We have read with interest the article by John C. Wagner, published in the June issue of *Metal Progress*, entitled "High-Silicon Aluminum Casting Alloy". This paper raises a number of interesting points regarding both the mechanism of the modification process and the suitability of dilute phosphor-copper as a "modifying" agent for hypereutectic aluminum-silicon alloys.

The effect of phosphorus additions to hypereutectic aluminum-silicon melts is to refine the primary silicon phase without affecting the structure of the eutectic matrix. The well-known modification treatment of eutectic and hypo-eutectic alloys with metallic sodium or sodium salts results in the refinement of the eutectic structure and has little effect on the crystal size of the primary constituent. In order to determine the effect of various additives to aluminum-silicon alloy melts, it is of the utmost importance to differentiate between the refinement of the major phases present. Thus the phosphorus treatment is not a modification treatment in the true sense.

Investigations carried out in the research laboratories of Foundry Services and by Lund of the University of Birmingham, indicate that phosphorus added to a hypereutectic aluminum-silicon melt forms nuclei of aluminum phosphide. This compound possesses all the qualities which favor nucleation of silicon, such as an identical lattice structure and very similar lattice parameters. It is believed that the introduction of nuclei of aluminum phosphide

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MoSi<sub>2</sub> is not attacked by most inorganic acids including aqua regia. It does react slowly with HF and rapidly with mixtures of HF and HNO<sub>3</sub>. It resists attack by aqueous solutions of alkalis but is easily dissolved in molten alkalis. It is extremely resistant to liquid sodium, zinc, bismuth and gallium. Fluorine and chlorine attack the disilicide but a bromine-hydrogen stream has no effect at red heat.

Hot-pressed MoSi<sub>2</sub> at 1800° F has a stress-rupture strength far superior to cemented carbides, cast and forged alloys, cermets and unalloyed molybdenum metal. The short-time tensile strength at 2200° F is 42,800 psi; modulus of rupture 55,000 psi. However, the use of MoSi<sub>2</sub> above 1800° F may be limited by a rapidly decreasing creep strength. This limitation may be modified by addition of an oxide to the disilicide.

High purity MoSi<sub>2</sub> powder is now commercially available from the Electro Metallurgical Company, P. O. Box 580, Niagara Falls, N. Y.; Fansteel Metallurgical Corporation, North Chicago, Ill.; and Sylvania Electric Products, Inc., Towanda, Pa. It can be formed by hot-pressing, sintering or casting. The disilicide can also be coated on various materials by vapor deposition. For further information on molybdenum silicides, write Dept. 5 for our bulletin "Refractory Molybdenum Silicides", Climax Molybdenum Company, 500 Fifth Avenue, New York 36, New York. It includes information recently released by the National Advisory Committee on Aeronautics.

# CLIMAX MOLYBDENUM

## Al-Si Alloy . . .

causes the refinement of the primary silicon phase and prevents the modification of the eutectic when the alloy is poured into a chill mold.

The most recent theories which attempt to explain the modification of eutectic aluminum-silicon alloys suggest that modification is the result of supercooling due to the inactivation by sodium of silicon-nucleating

particles present in the melt. On the other hand, the addition of phosphorus produces nuclei which prevent supercooling and encourage the solidification of primary silicon in a much finer form.

As part of our extensive research program referred to above, we have carried out an investigation to determine the effects of sodium and phosphorus additions on the microstructure of a binary 20% aluminum-silicon alloy. Figure 1 shows the struc-

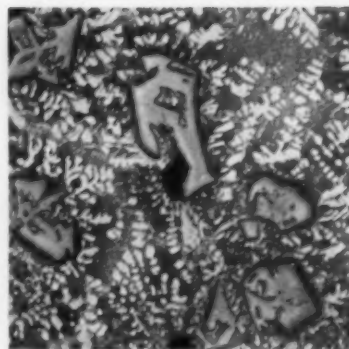


Fig. 1 — Untreated 20% Silicon Alloy.  
All micros 100 X

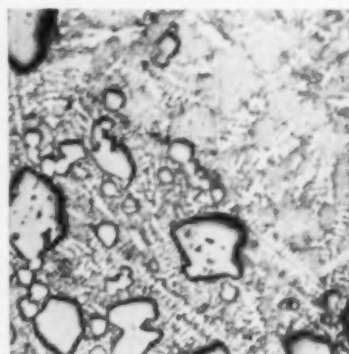


Fig. 2 — Modified With Sodium Salts



Fig. 3 — With Phosphorus Copper

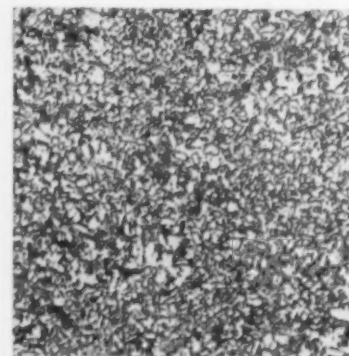
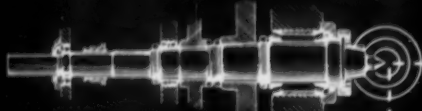


Fig. 4 — Improved Refinement With  
New Phosphorus-Bearing Additive

## Cincinnati Sub-ZEROing in FOR ACCURACY

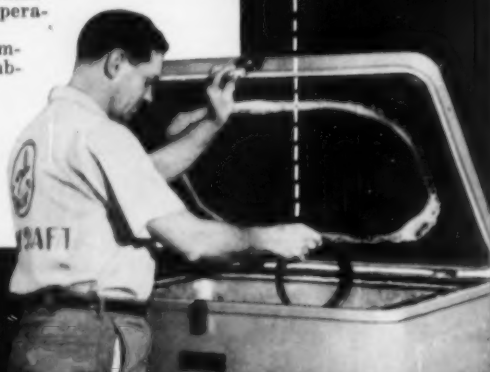
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bearing raceways of  
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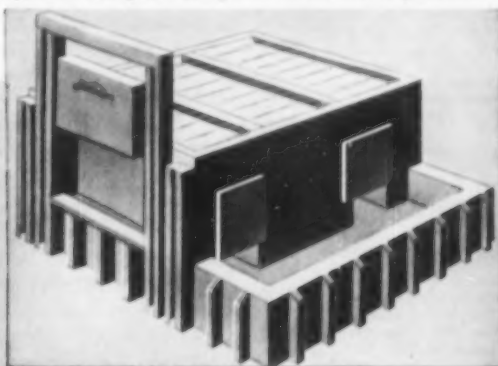
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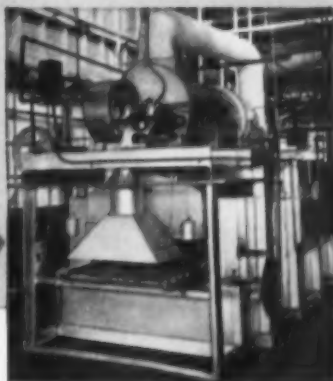


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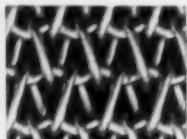
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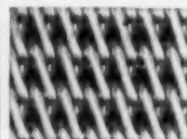
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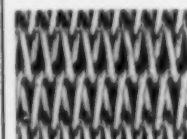
**BALANCED**—High tensile strength, low ultimate cost belting for operation up to 1300°F. Resists distortion. Designed for straight travel.



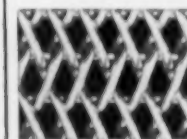
**DUPLEX**—Compact structure of great density provides high tensile strength, while close mesh provides smooth surface for carrying small parts.



**ROD-REINFORCED**—Highest tensile strength and low thermal capacity. Recommended for high temperature work, up to 2100°F. Undergoes minimum elongation and width contraction.



**GRATEK**—Close spirals retain the advantages of balanced weave, while adding strength. For cold, medium and some high temperature applications.



**DOUBLE BALANCED**—A widely used weave combining open mesh of balanced weave with the strength of Gratek. For cold, medium and some high temperature applications.

As you know, woven wire conveyor belts are widely used for combining movement with processing in many continuous metalworking operations—brazing, annealing, sintering, quenching, tempering, washing, etc. Heat treaters, particularly, find that in all phases of their operations, belt-to-belt flow through processing eliminates manual handling, increases production efficiency and product uniformity.

However, there is no single type of belt construction suitable for all operations. Some must withstand the rigors of higher temperature service—up to 2100°F.; some require fine mesh for handling small parts; others must resist the corrosive attack of pickling processes and cooling operations. That's why Cambridge has nine basic weaves available in any metal or alloy. The five shown here are the most widely used in the metalworking industry.

There are several factors that generally influence selection of weave, mesh size and metal or alloy from which the belt will be woven. Among them are: size and shape of the parts to be handled, temperatures to which belt will be subjected, presence of wet or corrosive conditions. Even after these have been decided, overall belt construction must be designed to meet individual requirements—type of drive, selva, support and special surface attachments must be selected.

You can see, then, that designing for continuous processing with woven wire conveyor belts is not a simple "nuts and bolts" job. Ramifications build up rapidly to demand the service of a specialist. That's why Cambridge maintains a staff of competent Field Engineers to help you select the Woven Wire Conveyor Belt to make your installation most efficient. You can rely on the experience of these engineers to specify just the right belt for you. In addition, they are thoroughly familiar with basic conveyor design. For the name of your nearest Cambridge Field Engineer, look under "Belting, Mechanical" in your classified telephone book. Or, write direct. Also ask for Special Report, "6 WAYS to Increase HEAT TREATING PRODUCTION", and 130-page Reference Manual of specifications and design information. THE CAMBRIDGE WIRE CLOTH CO., DEPARTMENT B, CAMBRIDGE 10, MD.



## Al-Si Alloy . . .

ture of the untreated alloy cast into a chill mold. The results of modification with sodium salts are shown in Fig. 2. It is seen that the eutectic phase has been noticeably refined although the primary constituent remains relatively unaffected. The refinement obtained with phosphor copper is shown in Fig. 3 but this is not nearly as marked as that shown in Fig. 4. This very fine structure was obtained by treating the molten alloy with a phosphorus-bearing material which was developed as the result of the research investigation.

The results tend to show that although phosphor copper tends to refine the primary phase it is not the most efficient agent for introducing phosphorus into an aluminum-silicon melt. In addition, it suffers from other disadvantages. The rate of solution at normal temperatures of phosphor copper in aluminum-silicon melts is extremely slow. This may be speeded up either by raising the temperature or by continuous stirring but neither method is recommended. It is not always permissible to increase the copper content of an alloy melt, nor is the chilling action of large quantities of dilute phosphor copper a desirable feature.

In the past, alloys of aluminum containing 20% silicon or more have been considered to be of academic interest only, but recent developments in piston design, particularly in Europe, have created new interest in these alloys and further investigation into the effects of trace elements in these alloys will be a very rewarding field of research.

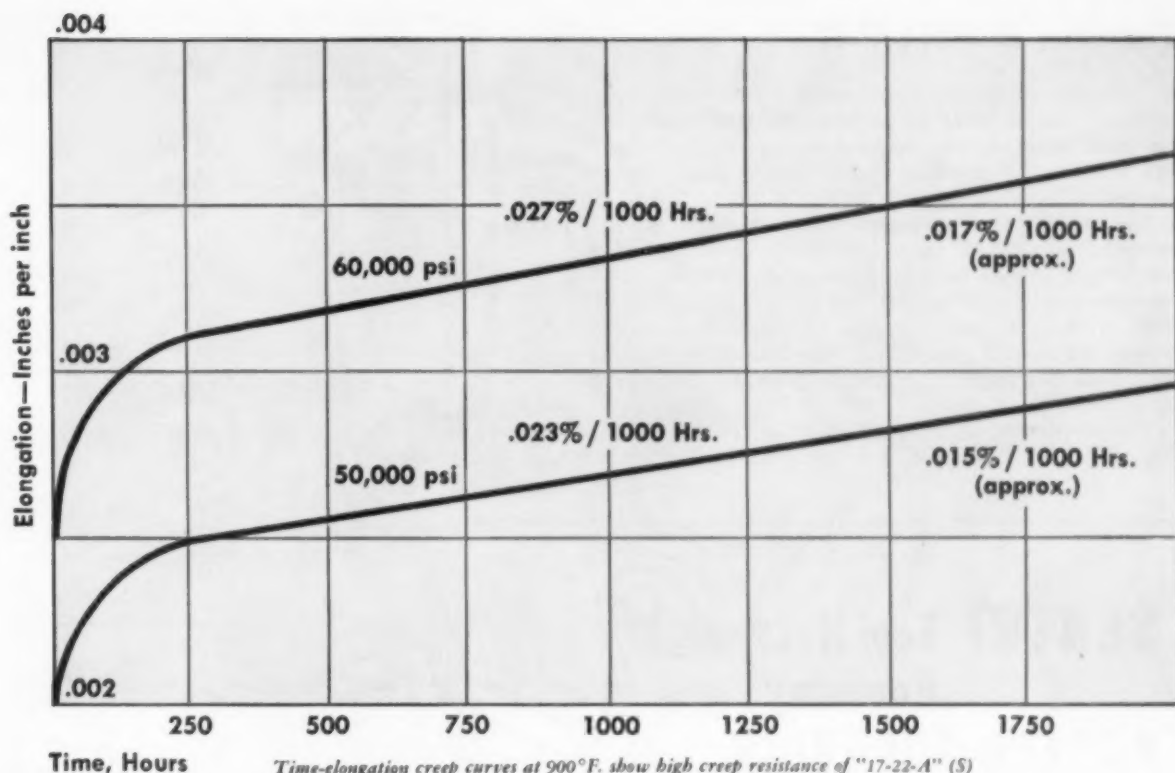
M. G. NEU

Foundry Services (Overseas) Ltd.

## Properties of MST 6Al-4V May Also Be Enhanced

NILES, OHIO

In the article "Enhanced Properties in 17-7 Stainless" which appeared in the July 1958 issue of *Metal Progress*, the data presented for annealed MST 6Al-4V are substantially correct. However, this alloy is also heat treatable. In the solution treated and aged condition,



## How to get high turbine alloy performance with low alloy steel

If you produce gas turbine parts or other parts that operate at temperatures as high as 1000 degrees F., you may feel you have to use an expensive high alloy steel.

But you can make parts that will do the same job, and save strategic alloys, using "17-22-A" (S) steel made by the Timken Company.

This steel helps you cut costs because it contains only 3% alloy. Yet it gives excellent creep resistance up to 1000 degrees F. The graph above shows it at 900 degrees F.

There are other advantages. "17-22-A" (S) resists heat checking and thermal cracking. It is readily work-

able up to 2300 degrees F. It's easy to machine and weld. And maximum high temperature properties can be developed by normalizing and tempering, minimizing the possibility of distortion and quench cracking.

For complete information on "17-22-A" (S) steel, and its companion analysis, "17-22-A" (V), recommended for temperatures up to 1100 degrees F., write for Technical Bulletin No. 36A. And for help with your high temperature steel problems, call upon our technical staff. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

## Properties of MST6Al-4V . . .

It is metallurgically more comparable to the precipitation hardened stainless steel. In addition, the MST 6Al-4V alloy has much better elevated-temperature properties than the 8% Mn titanium alloy which is a good forming sheet alloy not recommended for use above 600° F.

The short-time elevated-temperature ultimate and yield strengths for 17-7 PH and MST 6Al-4V, heat treated to 180,000 psi. ultimate tensile strength are shown in Fig. 1. The titanium alloy was water quenched from 1750° F., aged at 900° F. for 2 hr. and air cooled. The short-time elevated-temperature strength of heat treated MST 6Al-4V exceeds that of 17-7 PH by a margin of at least 25% from room temperature up to 1000° F.

The comparative stress-rupture data for 17-7 PH, Ti-8Mn, and MST 6Al-4V (annealed bar) are shown in Fig. 2. Here

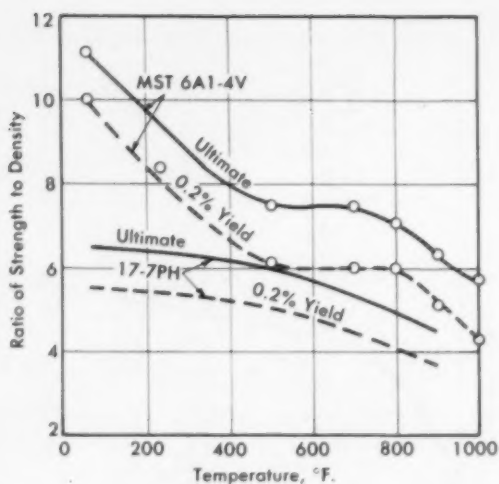


Fig. 1 - Tensile Properties of Heat Treated MST 6Al-4V and 17-7 PH at Elevated Temperatures

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PERFORMANCE RECORDS from countless Sentry installations such as that illustrated here have shown conclusively that the Sentry Diamond Block method of heat treating high speed steel provides maximum economy.

The positive Diamond Block Atmosphere hardens all high speed and air hardening steels, including lower cost moly steels, consistently and without spoilage, true to size

and completely free from scale or decarburization. For highest quality tool production use the proved superior economy of a Sentry Electric Furnace featuring the efficient Sentry Diamond Block Atmosphere. Consult Sentry for your own proof . . . demonstration hardening of your tools at no cost.

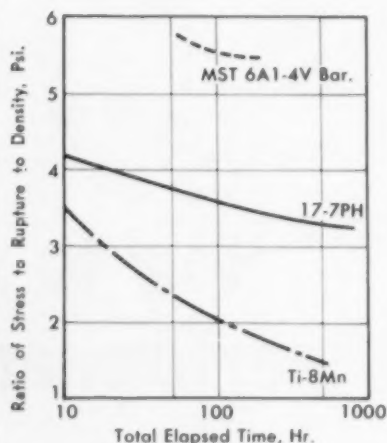


Fig. 2 - Comparison of Stress-Rupture Properties at 800° F.

again the superior properties of MST 6Al-4V are demonstrated. Although the stress-rupture strength of annealed MST 6Al-4V sheet is somewhat lower than that of the annealed bar tested, heat treatment will markedly improve its stress-rupture strength. The MST 6Al-4V alloy is one of the most important alloys in the titanium industry today because of its outstanding properties up to 800° F., its excellent strength-weight ratio and its availability in a wide range of mechanical properties and mill forms.

G. W. BAUR

Superintendent of Metallurgical Research

Mallory-Sharon Titanium Corp.

(More Correspondence on p. 120)



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*...and in high speed steels,*  
**nothing beats REX**

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**M**ASTERMET alloys are premium materials compounded to improve your product... *at no extra cost.* Alloys are made from *prime materials only*... then alloyed under exact time and temperature control. The latest degasification methods assure a clean, sound product.

What's more, MasterMet alloys are made to *compensate for your melting losses*... their chemistry meets all similar specifications.

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each lot you get *certification* of exact chemistry—there's no guesswork. In addition, MasterMet alloys are packed in easy-to-handle, clearly marked containers to simplify selection and storage.

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Cannon-Muskegon now offers vacuum-melting facilities for the production of iron-, nickel- and cobalt-base alloys up to temperatures of 3100°F... and special alloys for industry... in ingots or cast billets. We are ready to provide cleaner, stronger and more ductile alloys for remelt... sample development and production of vacuum process castings... and cast ingots for forging, extruding or machining.



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\*(R) International Nickel Corporation

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**METALLURGICAL SPECIALISTS**

## Uranium Separated by Gaseous Diffusion

WASHINGTON, D.C.

In the June 1956 issue of *Metal Progress* there appears a reprint of an article from the *Manchester Guardian Weekly* regarding stocks of nuclear explosives. Three times in this article the author mentions "thermal diffusion" in connection with the Oak Ridge U<sup>235</sup> plant. This is a serious error; the only producing plant in Oak Ridge has operated on the gaseous diffusion principle since the war.

In the report in 1945 by H. D. Smyth entitled "Atomic Energy for Military Purposes", it was reported that the thermal diffusion and electromagnetic separation methods were discontinued in favor of the more efficient gaseous diffusion process for isotope separation. Since then the advantages of gaseous diffusion have become very well known. It is surprising to discover that ten years later the "Scientific Correspondent" of such a well-known publication should be ignorant of this.

DAVID K. FELBECK

Executive Director

Committee on Ship Steel

National Academy of Sciences

## Magnetic Oxide "Etchant"

WHITING, IND.

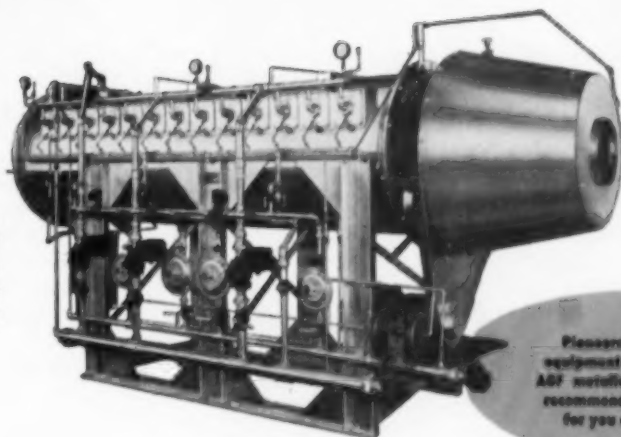
During the past five years, we have been using a colloidal magnetic oxide "etch" which apparently was devised by W. C. Elmore in 1938, and subsequently modified and described by E. A. M. Harvey in *Metalurgia*, Vol. 32, June 1945, p. 71 to 72. Even though this "etchant" has been in use for almost twenty years, many metallurgists are unaware of its existence. Others prefer to ignore it because of the difficulty in its preparation described by the previous authors. Since it can be used to detect minute amounts of ferrite in Type 304 stainless steel as well as to distinguish between ferrite and austenite in experimental steels, it is unfortunate that it has not found wider acceptance.

By the technique described below we have found that the preparation

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# poor paint adhesion?

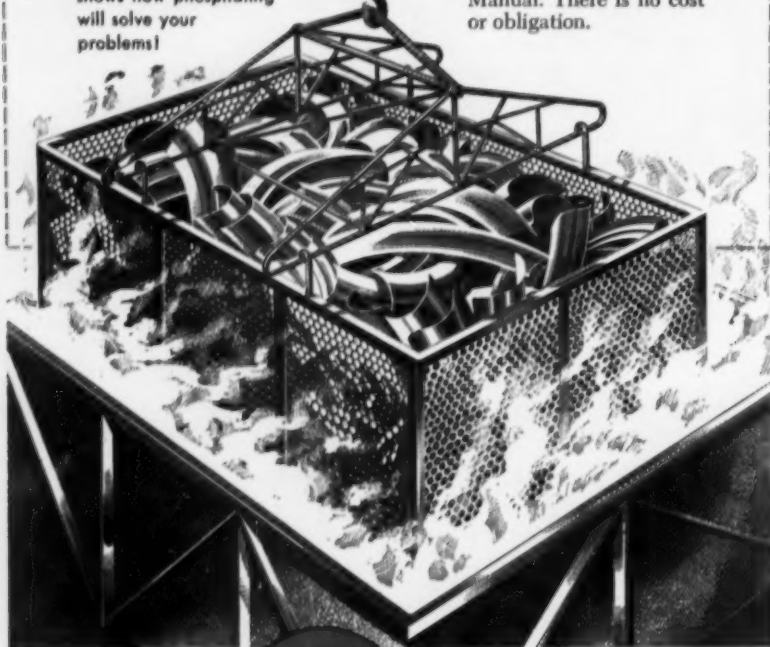


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## Etchant . . .

of the "etchant" is almost foolproof:

1. Dissolve 2 g.  $\text{FeCl}_2 \cdot 4 \text{H}_2\text{O}$  and 5.4 g.  $\text{FeCl}_3 \cdot 6 \text{H}_2\text{O}$  in 300 ml. of hot water. Add 50 ml. of a 10% solution of  $\text{NaOH}$ .

2. Filter the black precipitate in a Beuchner funnel and wash with distilled water three times.

3. Transfer the black precipitate to 300 ml. of 0.30 normal  $\text{HCl}$  solution and stir well. Add 5 ml. of a neutral detergent (Kodak's Photo-Flo) and boil until the black precipitate becomes a deep chocolate brown which may require 15 to 30 min. If the soap solution has a pH greater than 7 the particles will coagulate.

4. Filter hot to remove nondispersed oxide.

In magnetizing the sample, we have found it more convenient to place a bakelite-mounted specimen within any one of a variety of solenoid coils which are available in discarded mercury relays. Although these coils can be energized by an ordinary lead storage battery, an electrical source furnishing an excess of 40 v. d-c. will yield the best results. As Miss Harvey states, "a drop or two of the colloidal magnetite placed on the magnetized specimen will give an ample supply of sol products for forming a pattern."

GEORGE F. TISINAI

Assistant Project Engineer  
Standard Oil Co. (Indiana)

## Holder for Small Metallographic Specimens

BRISTOL, CONN.

In our routine metallographic work, we are faced with the problem of mounting small sections of wire and springs in bakelite for examination and maintaining their orientation in the mounting operation. That old favorite, Scotch tape, has proved to be a useful tool. We stick the samples into a small square of tape, sticky side up, and they adhere with enough rigidity to make mounting easy for the most fumble-fingered metallurgist.

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Research Metallurgist  
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You can use the new ratings in calculating performance of Microvac pumps, and in selecting the most advantageous pump size for your application. By capitalizing on this extra capacity, you may often be able to use a smaller, more economical Microvac model than indicated by previous calculations.

Ideal for pilot plant or production processes, Microvac pumps are designed for exceptionally low maintenance. Oil leakage at the shaft is eliminated by a unique mechanical face seal. There are no stuffing boxes. Lubrication is fully automatic. Intake screen filter keeps out dirt and scale. Oil line filter protects bearings and shaft seal.

Over their entire pressure range, Microvac pumps give high efficiency . . . are widely used by themselves or as roughing pumps with booster or diffusion pumps. Call the nearest Stokes office for a consultation on your specific vacuum application.

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**STOKES**

# Personal Mention



**A. J. Langhammer**

Thirty years of work with Chrysler Corp., most of them running the Amplex Div., has brought retirement to "ANDY" LANGHAMMER ☼, one of the best known and most cordially liked men in the industry. He is truly a self-made man. He quit school after the fifth grade and apprenticed himself as a toolmaker. His recreation was swimming and boat racing on the Ohio River. The craft, "Rambler I", was a row boat owned by the Langhammer brothers. One day a yawl was upset by the paddle wheel of a passing steamer and Andy saw a boy disappear under the ship. He went after the boy and fished him out—a particularly hazardous feat which won him a Carnegie Hero Medal and funds to finance preparation for college and his studies at the University of Cincinnati. There he was an outstanding student in mechanical engineering. On graduation he spent nine years with Packard, Thompson and Black (management engineers) and C. G. Spring and Bumper Co. before joining Chrysler.

He was head of Chrysler's marine division for some time, but his principal task with Amplex has been to perfect bearings and other parts made of powder metals. As a measure of the quality of this work in powder metallurgy, it may be mentioned that he was awarded the Achievement Medal of Stevens

Institute of Technology in 1948.

A bachelor himself, he likes to talk about boys. His oft-expressed opinion is that if parents will start boys early to do things and encourage them to finish what they have started, the desire for achievement will be implanted which will carry on through life.

Langhammer's opinions should carry weight. He's the product of the course he recommends.

The outstanding characteristic to new acquaintances is his thoughtful generosity as a host. A trip around Lake St. Clair on his ketch, "Rambler", is not soon forgotten. To his associates he is an exacting and respected leader and a loyal friend.

**Fred W. Boynton** ☼ recently was named industrial products sales manager in the Great Lakes sales region of Reynolds Metals Co., Louisville, Ky. Coming to Reynolds in 1947, Mr. Boynton was director of industrial markets in the Louisville sales office before his new appointment.

**C. F. Boyer** ☼ has been appointed special assistant to the manager of sales, alloy tube division, Carpenter Steel Co., Union, N. J. Joining the Carpenter organization in 1943, Mr. Boyer has been southeastern territory sales manager for the past nine years with headquarters in Atlanta, Ga. In his new assignment he will continue to operate from Atlanta.

**Wayne L. Besselman** ☼, formerly section head in charge of development and production engineering on heat treating furnaces at Leeds & Northrup Co., Philadelphia, has been named coordinator of technical employment for the company.

**Forrest Stretmater** ☼ has joined the sales division of Reynolds Metals Co., Louisville, Ky., as chief metallurgical engineer. Mr. Stretmater was previously employed for 19 years with the Servel Corp., Evansville, Ind., last holding the position of chief metallurgist of all Servel's manufacturing divisions.



**Francis T. McGuire**

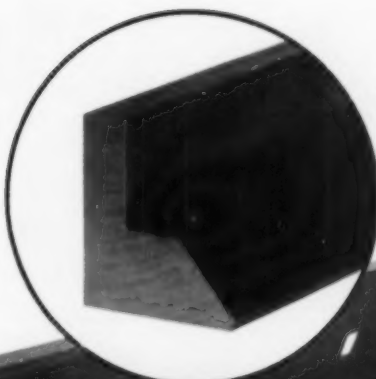
**FRANCIS T. MCGUIRE** ☼ has been promoted to the position of works manager of the John Deere Harvester Works of Deere & Co. Since 1949 he has been manager of the company's materials engineering department in Moline, Ill.

After receiving a degree in mechanical engineering and a doctorate in metallurgy from the University of Notre Dame, he taught for a couple of years at the University of Kentucky; he then spent three years as laboratory director for Republic Steel's Chicago plant and another three years as plant manager of Sibley Machine & Foundry Co., South Bend, Ind.

Dr. McGuire is a member of the Advisory Committee for Armor Piercing Projectiles and the Ordnance Department's Defense Research Committee. He is a past chairman of the ☼ Publications Committee and has served on the Metals Handbook Committee. Among his other professional society activities is membership on the Program and Papers Committee on Gray Iron of the American Foundrymen's Society.

**John J. Vreeland** ☼, previously products control head and technical service metallurgist at the Cleveland, Ohio, mill of Chase Brass & Copper Co., has been named staff manager, sheet and strip, at the Waterbury, Conn., headquarters of the company. Since joining Chase in 1930 as a research engineer, Mr. Vreeland has served in the fields of sales promotion and metallurgical engineering both in Waterbury and Ohio.

REVERE COPPER EXTRUSION shown attached to skirtboard before full assembly, which you can see below in exploded view. A matching bar, similar to the one shown is part of the "packaged" HANCO unit and is fastened to the opposite side of the screen. Units, in turn, are installed on the various types of Vibrating Screens made by HEWITT-ROBINS INC., Passaic, N. J., and are known as the HEWITT-ROBINS HANNON Electric Screen Heaters.



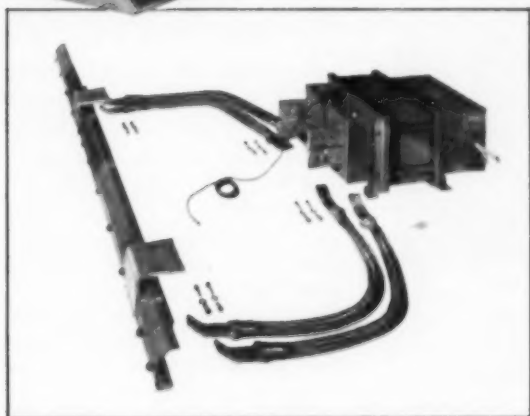
CLOSE-UP showing end of the Revere Copper Extrusion.



# Revere Copper Extruded Shape

in Hanco Electric Screen Heater

## out-performs former copper casting on 4 counts



"Customers of F. R. Hannon & Sons are now assured of many years of maintenance-free performance plus improved products."

Says T. W. HANNON, Vice-President, General Manager  
F. R. HANNON & SONS, Canton, Ohio

Mr. Hannon continued, "For a number of years we had experimented with many different types of materials which would be non-porous, free from any burrs or voids, capable of maintaining a straight leading edge and able to carry 1500 amperes at 5 volts. The Revere Copper Extrusion meets these requirements. And for the rugged use to which our machines are put it would be virtually impossible to maintain satisfactory operating results without the use of this extruded electrical conductor."

Perhaps there is a Revere Product that can help you give your customers a superior product, or help cut your production costs. You'll never know until you call the Revere Office nearest you and ask to have a T. A. (Technical Advisor) call. Why not make that call today?

### Here's the Score!

#### COPPER EXTRUDED SHAPE

- 1—12 foot mill lengths offer flexibility, eliminating both welds and scrap
- 2—Shape offers lack of porosity
- 3—Shape straightness is superior to casting, giving better electrical contact
- 4—Higher cost per foot, but cheaper over-all installation

#### COPPER CASTING

- 1—60" casting required additional welded joints
- 2—Casting gave porosity problem
- 3—Bow in casting presented difficulty when fastening screen firmly to contact
- 4—Initial cost was lower, but additional welds and scrap resulted in higher final cost, and an inferior finished product

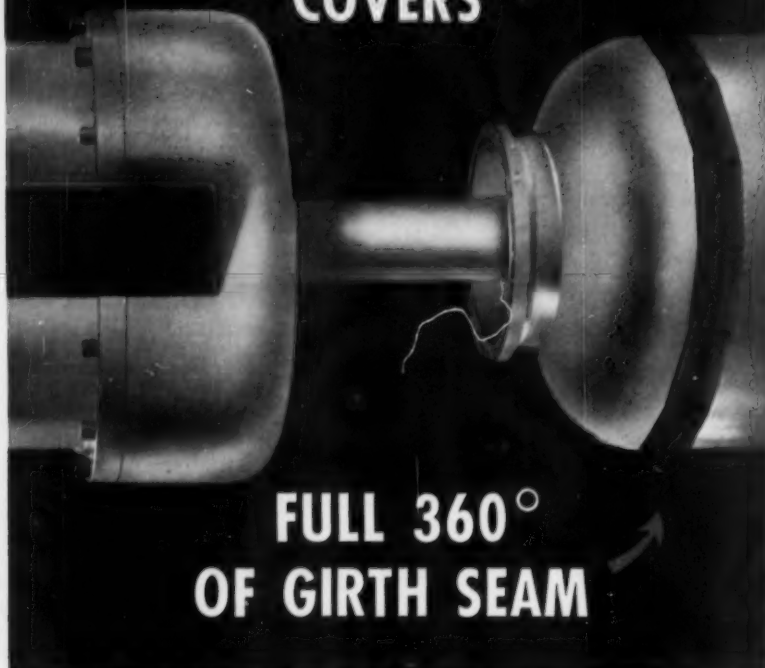
REVERE COPPER AND BRASS INCORPORATED  
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Instead of requiring separate exposures for many segments of a circumferential weld, the Van de Graaff's sideward-directed x-rays radiograph the entire seam in a single exposure, with excellent film density and sensitivity. Because of the very small focal spot, sharpness is retained even where short object diameters are involved.

The wide x-ray coverage of the panoramic beam is used with equal benefit in simultaneous radiography of groups of castings arranged in a circle; *only one exposure is required* to inspect a number of objects. Production radiography in applications previously considered impracticable results from Van de Graaff's speed and versatility.



For a complete analysis of the advantages of supervoltage radiography with the Van de Graaff, including case histories from American industry, write for our 24-page Bulletin R.

### HIGH VOLTAGE ENGINEERING CORPORATION

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## Personals . . .

**U. R. Jaeger** has assumed new duties as sales manager of the Western Brass Div. of Olin Mathieson Chemical Corp. Joining Olin Mathieson last year as eastern district manager for Olin Roll-Bond products, Mr. Jaeger had been acting sales manager.

**George C. Wilsher** is now vice-president in charge of engineering of Holcroft & Co., Detroit. Mr. Wilsher, who came to Holcroft in 1925, was formerly head of the engineering department.

**Andrew V. Wetzel** has been named chief metallurgist of the Cleveland Cap Screw Co.'s two Cleveland plants. Mr. Wetzel was a metallurgist with the company for more than seven years, and organized the metallurgical and physical laboratories there.

**Victor Little**, formerly technical consultant of the International Smelting and Refining Co., Raritan Copper Works, Perth Amboy, N. J., has accepted the position of plant superintendent of the Canadian Copper Refiners, Ltd., Montreal.

**Harold W. Rice**, an employee of Robertshaw-Fulton Controls Co. for more than twenty years, has been appointed director of the company's West Coast research and development laboratory in Los Angeles. From 1951 until his recent promotion, Mr. Rice was project supervisor at the laboratory.

**John H. Zauner** is now administrative assistant to the vice-president, engineering, of the Aerovox Corp., New Bedford, Mass. Prior to his recent appointment, Mr. Zauner was general manager of the Crowley Div. of the corporation.

**R. P. Frohberg** was recently appointed chief of the production development laboratory of the Rocketdyne Div., North American Aviation, Inc., Los Angeles. He was formerly in charge of the metallurgy unit, materials and process group, in the engineering section of Rocketdyne.

**Harold W. Burney** was recently named manager of Metal Improvement Co., Hackensack, N.J. He previously worked in the Los Angeles shop of the company.

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**Superior super pressure quality tubing has been used to handle internal pressures from 15,000 to 100,000 psi—offers high fatigue strength, chemical resistance and burst pressure to spare**

In any industry, handling liquids and gases safely and efficiently under extremely high pressures can be done best by using only top-quality tubing. And Superior specializes in premium quality super-pressure tubing.

Superior produces this tubing from specially selected raw materials which have had the inside surfaces conditioned to remove fissures and other defects. In processing, special degreasing operations are performed on the tubing, and the inside diameters are sand blasted to insure a clear, smooth surface.

Two types of Superior super pressure tubing are available: a single wall mechanical tubing and a double wall, or composite unit, made from two thinner tubes.

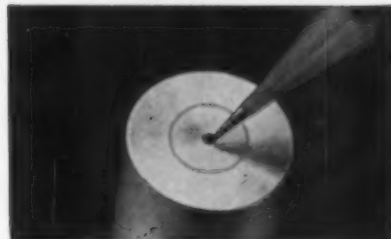
Super pressure tubing is produced in an annealed condition and in  $\frac{1}{8}$  hard

temper, and to mechanical properties specified by the customer.

This tubing is offered in the austenitic stainless steels, Types 304, 316, 321 and 347 and in AISI 4130 alloy steel. It is produced in sizes  $\frac{1}{8}$ " OD x  $\frac{1}{16}$ " ID up to  $\frac{3}{4}$ " OD x  $\frac{1}{8}$ " ID. Minimum order quantity for mill production is 50 ft. per size and analysis.

Superior rigidly inspects all super pressure tubing for defects such as fissures by visual and microscopic inspection methods. Each length is hydrostatically tested to 5000 psi—upon request, up to 60,000 psi.

If you have a tubing problem in high pressure processing—or of any other nature—call on Superior. Write Superior Tube Company, 2008 Germantown Ave., Norristown, Pa., for Data Memorandum 22.



The composite type stainless super pressure tubing offers the advantage of having the inner and outer tubes independently worked to mechanical property requirements and of different alloys being combined for strength and corrosion resistance.

SUPER PRESSURE TUBING MINIMUM BURSTING PRESSURES FOR AUSTENITIC STAINLESS STEELS AND 4130 ALLOY STEELS				
MAXIMUM WALL				
OD	.053	.095	.156	.218
$\frac{1}{8}$	*97,200 84,400			
$\frac{1}{4}$	*40,200 34,800	82,000 71,000		
$\frac{1}{2}$	*17,400 15,000	33,500 29,100	62,500 54,000	
$\frac{3}{4}$	*13,600 11,800	25,000 21,600	47,600 40,300	72,600 63,000

\*Top figures all Austenitic Stainless Steels  
Bottom figures all 4130 Alloy Steels

## Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to  $\frac{3}{4}$ " OD—certain analyses in light walls up to  $2\frac{1}{2}$ " OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. • Raymond 3-1331



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OUR OWN  
CUSTOMIZED  
CONVEYOR  
AS EASILY AS...**

**ONE ...**



**TWO ...**



**THREE ...**



## WITH **MAY-FRAN** STANDARD COMPONENTS

Through standardization, MAY-FRAN now makes it possible to assemble mass produced components into virtually any type of conveyor to handle a wide range of products or materials.

This program is cutting costs for manufacturers because . . . it means they can dis-assemble their conveyors for use in other plant locations . . . it means conveyors can be modified in almost any way at minimum cost.

Pre-fabricated sections are available rapidly and inexpensively. Straight sections . . . concave or convex sections . . . take-up charge and discharge-end sections can be furnished to meet specific requirements of belt width as well as load bearing and volume capacities.

# MAY-FRAN

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Write today  
for complete  
information.



## Personals . . .

**Albert Marsden** ⚙, formerly plant metallurgist at Light-Alloys Ltd., Haley, Ont., has joined Morrow Screw & Nut Co., Ltd., Ingersoll, Ont., as a plant metallurgist.

**Robert F. Frazure** ⚙ has been named manager in charge of the new Phoenix, Ariz., sales office of A. Milne & Co., New York.

**Waldemar Naujoks** ⚙ recently joined Kropp Forge Co., Chicago, as manager of engineering. Mr. Naujoks was formerly technical director of the Drop Forging Association, Lansing, Mich., and before that was vice-president and general manager of Globe Forge, Inc., Syracuse, N.Y.

**Ernest L. Layland** ⚙, formerly a supervising engineer in the metallurgical application section of the materials engineering department, Westinghouse Electric Corp., Pittsburgh, has been promoted to manager of the section. Other recent appointments in the materials engineering department include **Frank Emley** ⚙, a member of the department since 1949, who has been named supervisor of the powder metallurgy development group. **Herman D. Greenberg** ⚙ was also appointed supervisor of the ferrous application group and **William J. Reichenecker** ⚙ has been promoted to supervisor of the nonferrous application group.

**E. W. Chapman** ⚙ has been promoted to secretary of the S. G. Taylor Chain Co., Hammond, Ind. Affiliated with the company for 22 years, Mr. Chapman will retain his title and duties as assistant sales manager in addition to his new office.

**James D. Livingston** ⚙, a recent recipient of a doctorate degree from Harvard University, has been appointed a research associate in the metallurgy and ceramics research department at General Electric Research Laboratory, Schenectady, N.Y.

**William H. Griffith** ⚙ has been appointed supervisor of industrial advertising for the Kaiser Aluminum & Chemical Corp., Oakland, Calif. For the last four years, Mr. Griffith has been a member of Kaiser Aluminum's advertising and sales promotion department in Oakland.



we do

one

thing—

and we do it very well!

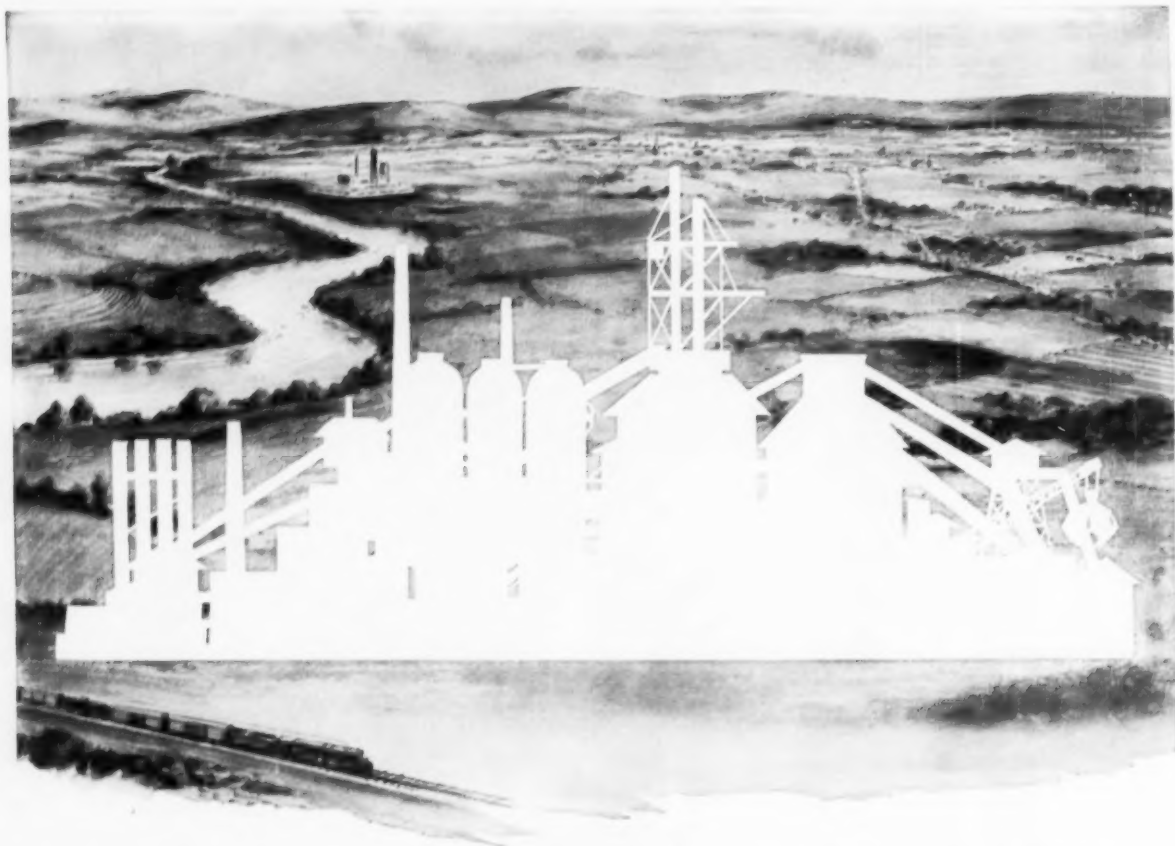


STRIP STEEL production is our specialty. From this you gain special benefits: experienced counsel on your strip applications...dimensional exactness...uniform quality, to speed product fabrication...the finish you want, in every coil. For superior quality and superior service in stainless, spring, alloy or clad metal strip steels *call Superior!*

**Superior Steel**

CORPORATION

CARNEGIE, PENNSYLVANIA



## There's a place for a Steel Mill on the N&W

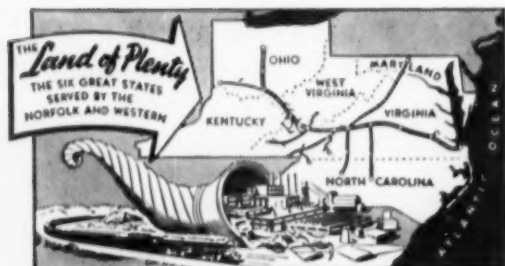
*Write, Wire or Call:*

**L. E. WARD, JR., Manager**  
**INDUSTRIAL AND AGRICULTURAL DEPT.**  
 Drawer MP-72B, (Phone 4-1451, Ext. 474)  
**Norfolk and Western Railway**  
**ROANOKE, VIRGINIA**

In the Land of Plenty you can build a steel mill virtually on top of almost unlimited supplies of the world's finest Bituminous Coal and high-calcium limestone. And you can avail yourself of short-haul advantages in transporting ore from the strategically located Port of Norfolk.

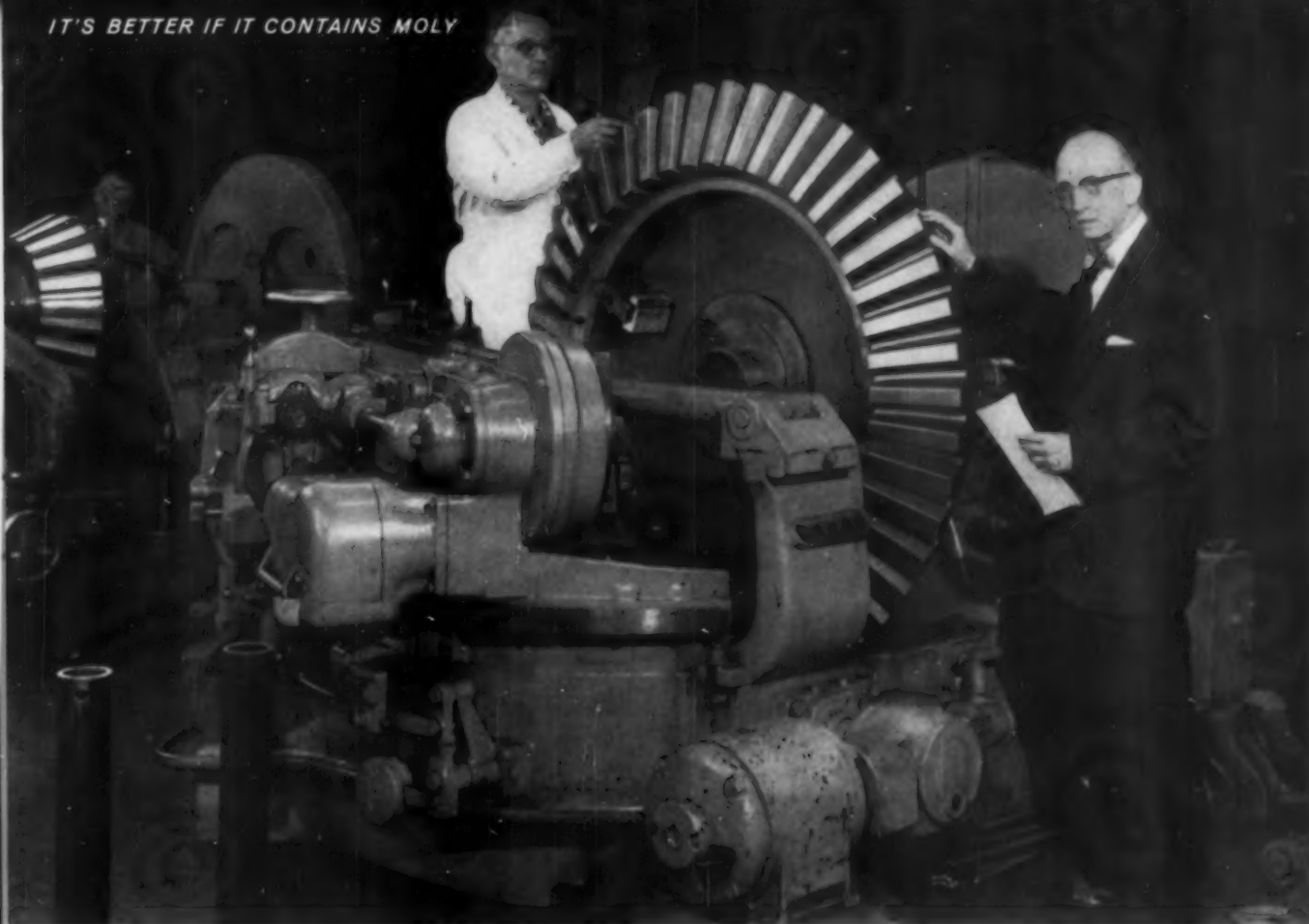
The water needed for steel production, on any logically conceivable scale, is available here, too.

Recent scientific studies have revealed some startling facts about the Land of Plenty in regard to its advantages for the steel industry. We invite you to contact our plant location specialists for detailed information, which will be furnished in confidence and without obligation.



# **Norfolk and Western** **RAILWAY**

IT'S BETTER IF IT CONTAINS MOLY



E. B. Smiley, Metallurgist for Illinois Gear & Machine Co., looks over setup of large, heavy duty bevel gear made from molybdenum

alloy steel casting. This gear has been rough turned, rough cut and heat treated to 269 to 302 Brinell before finish cutting.

## For Strength, Hardness and Machinability gear maker recommends Molybdenum Alloy Steels

"All of our gears are made to customer specifications, and in many cases these include the use of molybdenum steels," says Mr. Smiley, metallurgist for Illinois Gear & Machine Co. "When our customers specify heat-treated gears of plain carbon steel," Mr. Smiley continues, "we often recommend that they change to 4140 alloy containing molybdenum to achieve high strength and hardenability with good machinability."

Moly steels offer gear users many advantages over carbon steel. Their greater strength and toughness permit the use of smaller weight-saving gears to transmit a given amount of power. Reduced weight and size of gear housings and other components add to the economy of moly steels. And their higher endurance is an important safety factor.

The properties of moly steels are discussed in a new booklet "Moly Steels for Cast Gears". Full technical assistance is also yours for the asking. Write Climax Molybdenum Co., Dept. 5, New York 36, N. Y.

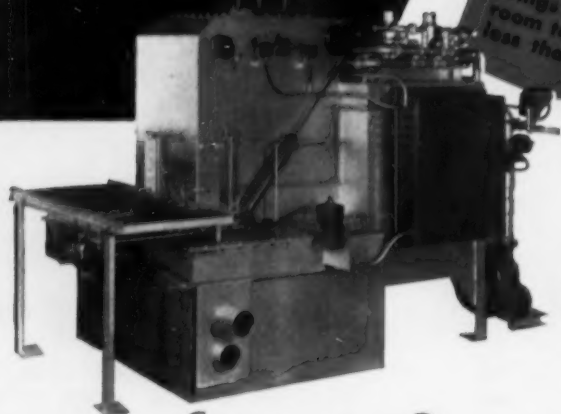
# CLIMAX MOLYBDENUM



# DOW

## Sealed Cycle

### CONTROLLED ATMOSPHERE BATCH-TYPE FURNACES



Model  
HA-400  
Shown

THE  
RIGHT

{ CAPACITY  
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FOR  
YOUR JOB!

Regardless of capacity, price or degree of mechanized operation you may require, each of these furnaces has DOW'S exclusive built-in generator and other outstanding DOW features that insure high quality work at lowest cost.

Every DOW furnace is designed with controlled furnace pressurizing, controlled quench oil circulation, and controlled atmosphere circulation . . . all proven advantages that mean cleaner stock . . . uniform hardness . . . minimum distortion.

Write for detailed literature.

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Phone: KENwood 2-9100

*First* WITH  
MECHANIZED, BATCH-  
TYPE, CONTROLLED  
ATMOSPHERE FURNACES

Model  
**J-800**  
Brings 800 lb. load,  
room temp. to 1500°F.  
less than 1 hr.

Model  
**HA-400**  
Brings 400 lb. load,  
room temp. to 1500°F.  
less than 1 hr.

Model  
**HB-200**  
Brings 200 lb. load,  
room temp. to 1500°F.  
less than 1 hr.

## Personals . . .

Rudolf H. Thielemann ☉ has been named chairman of the new department of metallurgy at Stanford Research Institute, Menlo Park, Calif. Before being given departmental status, metallurgy had been a section of the Institute's chemistry department. Mr. Thielemann was manager of this section for a year, and prior to that was development metallurgist for Pratt & Whitney Aircraft, East Hartford, Conn., for 10 years. Group heads named for the metallurgy department include Thomas Tietz ☉, physical metallurgy, and William R. Holman ☉, liquid metallurgy.

John Korthauer ☉ is now a technical engineer in the reactor design section of the aircraft nuclear propulsion department, General Electric Co., Cincinnati, Ohio. He was formerly affiliated with Western Electric Co., Winston-Salem, N.C.

Herbert M. Meyer ☉, formerly chief of the metals research branch, Watertown Arsenal, Watertown, Mass., is presently senior research metallurgist with Clevite Transistor Products, Waltham, Mass.

Fritz Koenig has severed his connection with the George Scherr Co., and has organized his own company, Opto-metric Tools, Inc. Mr. Koenig will be president and general manager of the new company.

John M. Mavec, Jr. ☉, formerly a student at Michigan College of Mining & Technology, is now working in the process engineering department of Cessna Aircraft Co., Wichita, Kans., as a metallurgist.

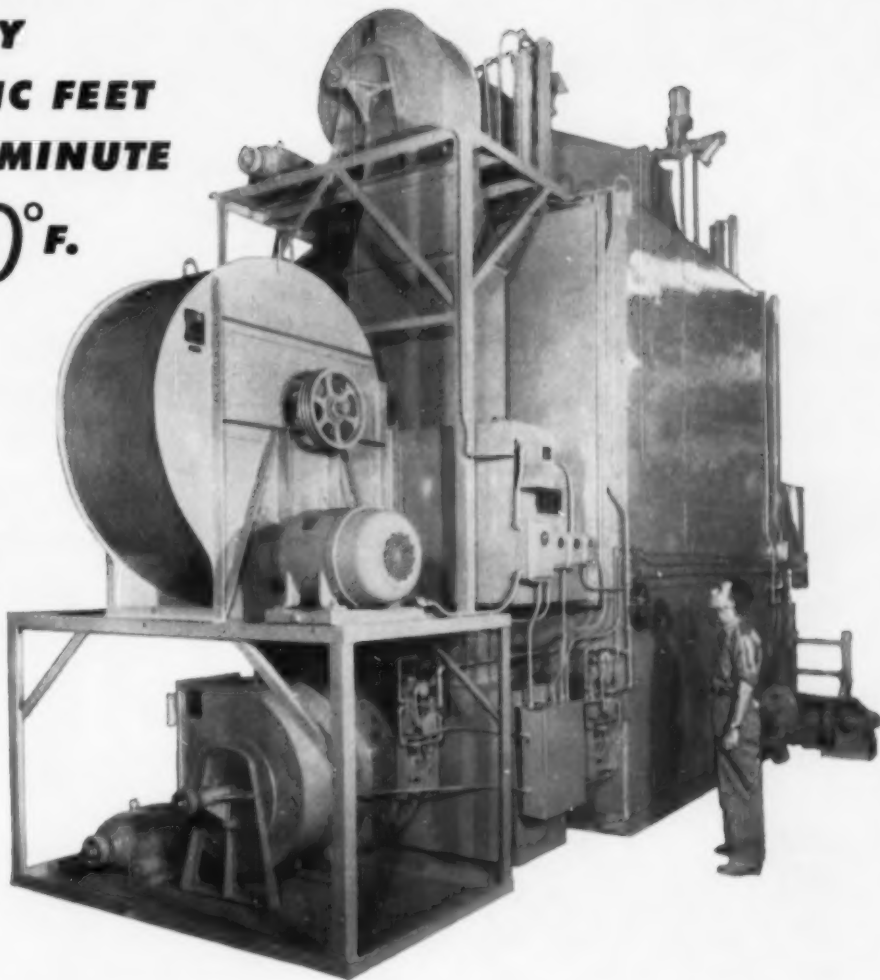
Robert E. Krueger ☉ has been named sales manager of Donner Scientific Co., Concord, Calif.

John Murphy ☉ has returned to the University of California to continue his studies toward a bachelor of science degree. He formerly was associated with the Southern Pacific Co., Sacramento, Calif.

Bernard Fuller ☉ has become Detroit district sales manager for the Hevi-Duty Electric Co., Milwaukee, Wis. Mr. Fuller has spent the last ten years with Minneapolis-Honeywell Regulator Co. in the Chicago office, and recently was industrial sales manager in Milwaukee.

**TO DRY  
12,000 CUBIC FEET  
OF AIR PER MINUTE  
TO -50°F.**

That's talking BIG!  
But it's the  
Guaranteed DRYing  
capacity of this huge  
Lectrodryer\*, now  
at work on  
titanium processing.



**Y**OU'LL SEE Lectrodryers of all sizes on all kinds of metallurgical jobs. This big drier, for example, safeguards sensitive titanium in the molten stage against attack by moisture. At the other extreme in size, tiny Laboratory Lectrodryers work with individual furnaces and machines making certain that gases fed to them are DRY.

Where controlled atmospheres must be DRY, your gas generator manufacturer will likely include a Lectrodryer along with his equipment. He's an expert on the use of special atmospheres for any metallurgical

purpose. Tell him your problem and ask him to recommend a method and apparatus for solving it.

Many manufacturers of finely finished metal products safeguard surfaces against fingerprinting and corrosion by DRYing workrooms and storage areas. Lectrodryers may work with refrigeration equipment to maintain constant temperatures and low humidities.

The book, *Because Moisture Isn't Pink*, shows various installations. For a copy, write Pittsburgh Lectrodryer Company, 317 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw Electric Company Division).

In England: Birlec, Limited, Tyburn Road, Erdington, Birmingham

In France: Stein et Roubaix, 24 Rue Erlanger, Paris XVI

In Belgium: S. A. Beige Stein et Roubaix, 320 Rue du Moulin, Bressoux-Liege

**LECTRODRYERS DRY  
WITH ACTIVATED ALUMINAS**

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MADE TO  
exacting  
standards  
of  
FINE STEEL MAKING

NOW SHIPPED IN EASY-TO-  
HANDLE 50-POUND DOUBLE  
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Round, solid, tough—Tru-Steel has everything you expect in steel shot—obtainable only through precision control of manufacturing processes, unsurpassed plant facilities and the know-how of specialists whose only business is the manufacture of steel shot. Tru-Steel sells and stays sold on the basis of test and comparison. Write us.

Sold and recommended by  
Pangborn Corp.  
Hagerstown, Md.

# TRU-STEEL® SHOT

Manufactured by  
STEEL SHOT PRODUCERS, INC.  
Butler, Pa.

## Personals . . .

**Rolf Weil** Ⓢ, formerly an associate metallurgist at the Argonne National Laboratory, Lemont, Ill., has been named an assistant professor in the department of metallurgy at Stevens Institute of Technology. Before joining the Argonne National Laboratory, Dr. Weil was a metallurgist with the Duquesne Smelting Corp., Pittsburgh.

**E. E. Tuttle** Ⓢ, since 1946 a representative of Leeds & Northrup Co., Philadelphia, in the Indiana area, is the manager of the company's new Indianapolis office. An active ASMember, Mr. Tuttle is currently chairman of the Indianapolis Chapter of A.S.M.

**Donald L. Erickson** Ⓢ has been named manager of engineering for the newly organized West Coast engineering division of Brooks & Perkins, Inc., Detroit. Formerly chief production engineer at the main plant in Detroit, Mr. Erickson has been located in the West Coast sales office of Brooks & Perkins for the past year.

**R. A. Colton** Ⓢ was recently elected chairman of the Metropolitan Chapter of the American Foundrymen's Society, one of the largest chapters of the Society composed of the New York-New Jersey metropolitan area. Mr. Colton has been associated with Federated Metals Div., American Smelting & Refining Co., New York, for the last ten years.

**Charles B. Cobun** Ⓢ, formerly affiliated with the Chicago district sales office of the Heppenstall Co., Pittsburgh, has been appointed manager of ring sales at the company's Indianapolis, Ind., plant. Mr. Cobun joined the company in 1951 as a sales representative in the Chicago district after long association with the U.S. Steel Corp.

**Eric R. Morgan** Ⓢ has joined the staff of Jones & Laughlin Steel Corp., Pittsburgh, as assistant director of research with supervision of process and physical metallurgy, analytical chemistry and coatings and corrosion research. Until his recent appointment, Dr. Morgan was assistant manager in the metallurgy department of the Ford Motor Co., Dearborn, Mich.



NRC Sales Engineer points to co-axial lead in NRC Model 2555 20-lb. Vacuum Induction Furnace. Co-axial leads are standard equipment in all NRC tilt-pour vacuum induction furnaces.

## Four Reasons Why CO-AXIAL LEADS Should Be Used in Every Tilt-Pour VACUUM INDUCTION FURNACE

NRC has built and operated more high vacuum furnaces than any other organization in the world. We've found that co-axial power and water leads pay for themselves many times over because:

**1. They reduce explosion hazards.** Steam and hydrogen explosions can result when a flexible lead fails and cooling water comes in contact with molten metal. Co-axial leads provide a positive water seal and resist burn-through caused by spattering or crucible failure.

**2. They cut power loss.** The inherent high frequency efficiency of a co-axial lead reduces voltage drop. Because a co-ax is shorter and of lower resistance

than a flexible lead, its use can reduce power loss by as much as 50%.

**3. They increase productivity.** Rapid crucible changes can be made with a co-axial lead. Positive seals against water and air leaks assure rapid pump-down and prevent work spoilage.

**4. They're long-lived.** We've never had to replace a co-axial lead. That's because they're rugged, and don't work-harden, the way other types do, from continued use. Impurities in the cooling water won't cause them to clog up either. And there's no rubber to burn or wear out.

NRC high vacuum products include: dehydrators, freeze driers, gas analyzers, impregnators, gauges, metallizers, pumps, valves, vacuum furnaces.



### NRC EQUIPMENT CORPORATION

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### NATIONAL RESEARCH CORPORATION

Dept. 110, Charlemont St., Newton Highlands 71, Mass.

Please send NRC Vacuum Furnace Bulletin ☐

Have your representative call ☐

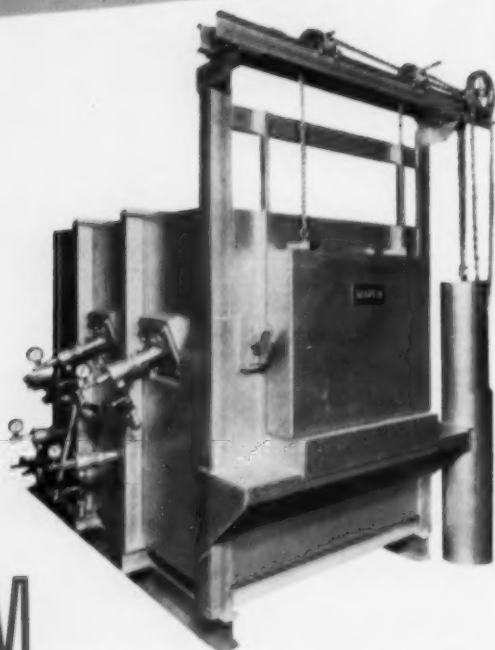
Name.....Title.....

Company.....

Address.....

City.....Zone.....State.....

# CUSTOM-BUILT and PDQ!



**M**ARTIN furnace shown was built for a leading manufacturer of aircraft engine parts. Advanced in basic design, it also incorporates several features which our customer felt certain from long experience would do their job better . . . and faster. As anticipated, this furnace is now out-performing all others on brazing operations, at temperatures up to 2500° F.

Why not ask this defense contractor?\*

You, too, may have some furnace ideas that will do your job better and faster. Write us today for information on building a MARTIN advanced design furnace to your requirements.

\* Name and details upon request.

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ADVANCED DESIGNS IN  
ALL TYPES OF FURNACES



industrial furnace division

MARTIN MANUFACTURING CO.

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DETROIT 3, MICHIGAN

## Personals . . .

**Robert K. Warren** ☼ has become a special representative in the sales department of Universal-Cyclops Steel Corp., Bridgeville, Pa. Mr. Warren was employed by Crucible Steel Co. for 27 years, and more recently served as representative in the Connecticut area for Hawkrider Bros., Boston, Mass.

**Charles R. Miller** ☼ has been named director of works accounting in the general office of Jones & Laughlin Steel Corp., Pittsburgh. An employee of Jones & Laughlin since 1933, Mr. Miller last held the position of chief accountant in the company's Cleveland works.

**G. M. Tauber** ☼ was promoted to supervising engineer at Leeds & Northrup Co., Philadelphia. Mr. Tauber joined Leeds & Northrup in 1923 as a draftsman, and has since served as a designer and design engineer in furnace engineering.

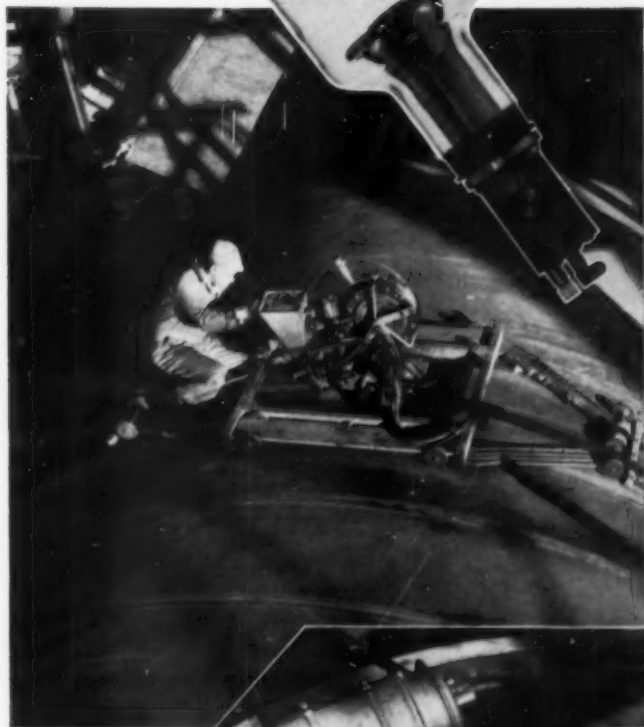
The Carpenter Steel Co., Reading, Pa., has announced the appointment of several men to managerial positions in the company. **Robert P. Uhl** ☼, former branch manager of the company's warehouse in Dayton, Ohio, has been named New York district manager. Associated with Carpenter since 1946, he was named Dayton manager in 1953. **Charles E. Miller** ☼ is now branch manager of the Houston, Tex., area. Mr. Miller, formerly a representative in that territory, has been affiliated with Carpenter since 1946. The new branch manager of the Detroit area is **O. T. Thompson** ☼. Joining the company in 1948 as a field representative, his last position was assistant branch manager in Detroit. Formerly a field representative, **J. C. Murray** ☼ is now assistant branch manager in the Pittsburgh area.

**E. S. Bumps** ☼, formerly supervisor of metallurgy, Studebaker-Packard Corp., South Bend, Ind., is presently employed as metallurgical contact engineer, product technical service department, Jones & Laughlin Steel Corp., Pittsburgh.

**Jack A. Sartell** ☼ has left the University of Wisconsin to accept a position as a research metallurgist at the Minneapolis-Honeywell Research Center in Hopkins, Minn.

# Pressure Hull Inspection for Nuclear Powered Submarines with

## **MACHLETT EG-250 X-RAY TUBE**



Electric Boat Division of General Dynamics Corporation must perform highly critical radiographic inspection on the thousands of feet of circumferential and transverse butt welds on the pressure hull of each submarine it constructs.

On the nuclear powered submarines constructed and now under construction the Machlett EG-250 x-ray tube is used for all large scale inspection of the pressure hull weldments.

One apparatus manufacturer alone has now used—in a wide variety of applications—more than one hundred EG-250 anode grounded x-ray tubes in gas insulated lightweight x-ray tubeheads.

For exacting inspection under adverse environmental conditions the Machlett EG-250 provides excellent, reliable performance.



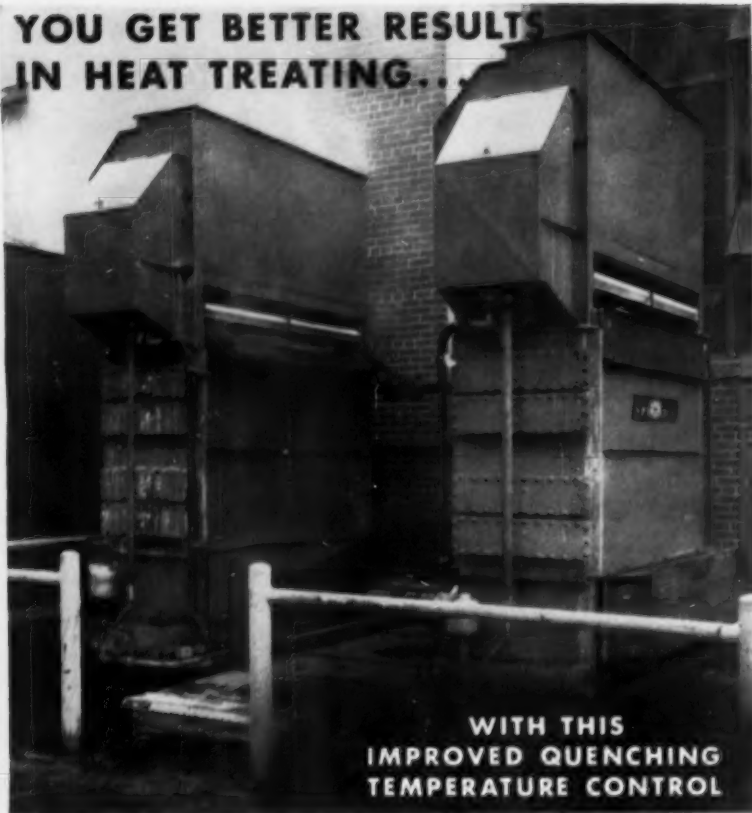
Machlett **EG-250** x-ray tube, used in portable gas insulated tubehead, is employed for weld inspection on pressure hull of nuclear powered submarine SSN 578, Skate.

**MACHLETT**

FIRST IN INDUSTRIAL ELECTRON TUBES

**MACHLETT LABORATORIES, INCORPORATED**  
**Springdale, Connecticut**

**YOU GET BETTER RESULTS  
IN HEAT TREATING...**



**WITH THIS  
IMPROVED QUENCHING  
TEMPERATURE CONTROL**

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● Use the **NIAGARA AERO HEAT EXCHANGER** to control the temperature of your quench bath and you remove the heat at its rate of input, always quenching at the exact temperature that will give your product the best physical properties. You get uniform results throughout the day's production, prevent losses, avoid rejections, increase your heat treating capacity.

The Niagara Aero Heat Exchanger transfers the heat to atmospheric air by evaporative cooling. It extends your quenching capacity without using extra water. It pays for itself with water savings.

In the installation illustrated the quench is caustic soda. Water also is accurately cooled and the system is easily kept clean. With an oil quench an extra advantage is to prevent flash fires.

You can cool and hold accurately the temperature of all fluids, air, gases, water, oils, solutions, chemicals for processes and coolants for mechanical and electrical equipment. With the Niagara Aero Heat Exchanger you have closed system cooling, free from dirt and scale.

*For further information write for Bulletin No. 120*

## **NIAGARA BLOWER COMPANY**

Dept. MP, 405 Lexington Ave.

New York 17, N. Y.

*District Engineers in Principal Cities of United States and Canada*

## **Personals . . .**

**Howard R. Noblitt** ☉ has accepted a position as assistant superintendent with the Gas Light Co. of Columbus, Columbus, Ga. Mr. Noblitt previously was associated with H. R. Miles and Assoc., Chattanooga, Tenn.

**Arthur H. Bauman**, formerly production metallurgist at Universal-Cyclops Steel Corp., Bridgeville, Pa., is presently employed as an alloy engineer at the Westinghouse Electric Corp.'s metals plant in Blairsville, Pa.

**Richard R. Webster** ☉ has been promoted to assistant director of research with supervision of instrument development and application of instrumentation to process control at Jones & Laughlin Steel Corp., Pittsburgh. Mr. Webster has been associated with Jones & Laughlin since 1937, last serving as assistant manager of metallurgical research.

**Richard G. Lang** ☉ has been appointed a sales representative for the Chicago district office of Heppenstall Co., Pittsburgh. Mr. Lang joined the company in 1948 at the Pittsburgh headquarters, and later served with W. P. Wooldridge Co., the Pacific Coast representative of Heppenstall. From 1951 until his new appointment, he was a sales engineer for the Detroit district office.

**Fredric H. Harf** ☉, formerly with the Detroit Arsenal, Centerline, Mich., has joined the Aviation Gas Turbine Div., General Electric Co., Evendale, Ohio, as a metallurgical methods engineer.

**Andrew W. Magnusson** ☉ is now research metallurgist in the metallurgical research laboratories of the Reynolds Metals Co., Richmond, Va. Prior to this position, Mr. Magnusson was a research assistant in the department of metallurgy, Case Institute of Technology, Cleveland.

**A. N. Holden** ☉ has been named manager of metallurgy for General Electric Co.'s Vallecitos atomic laboratory, which is scheduled to go into operation in 1957 near Pleasanton, Calif. For several years Mr. Holden was manager of physical metallurgy at Knolls Atomic Laboratory, Schenectady, N.Y., and more recently has been on special assignment at that laboratory.

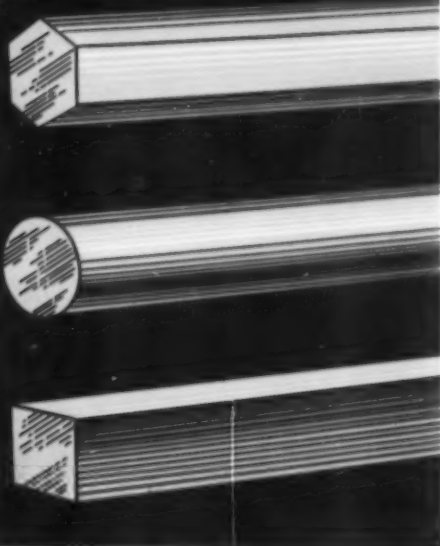
**GOOD AND STRAIGHT—** *won't whip!*



**CHASE®**  
free-cutting  
**BRASS**

**ROD • BAR • SHAPES**

Screw machines really purr along when you feed them Chase Free-Cutting Brass rod! Uniform lengths and straight lengths that won't whip, superior machinability, longer runs before regrinding tools, all mean more pieces per length, fewer rejects and less down time per machine. Order from your Chase warehouse!



**Chase**   
**BRASS & COPPER CO.**

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Milwaukee Minneapolis Newark New Orleans New York Philadelphia Pittsburgh Providence Rochester St. Louis San Francisco Seattle Waterbury

OCTOBER 1956

137

# NOW LEADED!

Now you can obtain the advantages of leaded 52100 Steel in round bar stock. The presence of lead acts as a lubricant, resulting in freer machining, quicker, cleaner cutting, better finishes and longer tool life. All these advantages are conducive to greater production at reduced costs.

PHONE OR WRITE TODAY  
FOR COMPLETE INFORMATION  
DEPT. I

**PETERSON STEELS, INC.**

UNION, NEW JERSEY

Detroit, Michigan • Chicago, Illinois

## Personals . . .

**C. K. Charles** has transferred from the U.S. Steel Corp. Fairless works, Fairless Hills, Pa., to the U.S. Steel applied research laboratory at Monroeville, Pa., where he is now a research technologist. Mr. Charles formerly was a metallographer at the Fairless works.

**N. C. Fick**, currently chairman of the Washington Chapter, has been appointed to the newly created position of program expeditor in the Office of Defense Mobilization in the executive office of the President, Washington, D. C.

**Francis B. Gurtner** has been transferred from the Detroit Transmission Div. to the Chicago Electro-Motive Div. of General Motors Co. While at Detroit Transmission, Mr. Gurtner held the position of plant metallurgist, welding; he now is experimental metallurgist, welding.

**Matthew J. Galvez** is now unit head of the fuel elements group, nuclear division, Glenn L. Martin Co., Baltimore, Md. Prior to his recent appointment, Mr. Galvez was employed at Sylvania Electric Products, Inc.

**Glen R. Larson** has been appointed sales engineer for the Hydraquip Corp., one of the firms represented by the Valvair Corp, Akron, Ohio. Mr. Larson, who will handle the Dallas-Ft. Worth, Tex., area for Hydraquip, was formerly chief engineer at the United Machine Co.

**L. R. Miller** has been named chief engineer of the Trent Tube Co., East Troy, Wis. Associated with the company since 1945, he was formerly chief metallurgist.

**David Helm**, vice-president in charge of research of the McKay Co., Pittsburgh, has been elected a director of the board of the company. Dr. Helm joined McKay as the company's first research fellow in 1936, when the McKay Fellowship was started at Mellon Institute in Pittsburgh.

**V. C. Vanderbilt, Jr.**, formerly a consultant and Purdue University professor, has joined Perfect Circle Co., Hagerstown, Ind., as chief research engineer.

## METALLURGISTS...



### Help develop the world's first nuclear powered fleet

Nuclear power offers tremendous advantage for naval vessels. From the fuel standpoint, cruising ranges are virtually unlimited—even at new high speeds. No refueling facilities will be required to replenish nuclear propulsion fuel. Therefore, the physical design of the fleet can be streamlined for greater efficiency and safety.

At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

These include: the development of fuel alloys; the development of clad alloys; fuel element development; and technical control of fuel elements and fuel and clad alloys. At Bettis you will have a choice of working in either Basic or Applied Metallurgy. You may prefer to conduct basic research in areas like these:

1) Solid phase transformation, 2) Corrosion kinetics

and mechanisms, 3) Effect of irradiation on metals, 4) Internal friction studies, 5) Study of equilibrium diagrams.

To do this, Bettis Plant needs farsighted men. Regardless of your interest, you can choose a place in the varied operations at Bettis Plant.

Atomic experience is not necessary.

What's more, Bettis Plant is in Pittsburgh's South Hills. Here you can enjoy good living in pleasant suburbs near the plant, and still be convenient to one of the nation's most progressive metropolitan areas.

Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

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## BETTIS PLANT Westinghouse



# Digests of Important Articles

## Statistical Treatment of Fatigue Data

Digest of "A Study of Statistical Treatments of Fatigue Data", by M. N. Torrey and G. R. Gohn, American Society for Testing Materials, Preprint No. 70, 1956, 25 p.

**A**LTHOUGH metal fatigue has been recognized for well over a century, the mechanism of fatigue failure has been studied in this country only since 1919. Even now our understanding of the mechanism of fatigue failure is not yet complete. New research tools, such as the electron microscope, have increased our knowledge of the characteristic behavior of metals and developments in solid state physics and in statistics have contributed much toward a more rational explanation of the causes of fatigue. Recent studies are so significant that A.S.T.M. Committee E-9 is now preparing a manual on the statistical treatment of fatigue data. The real need at present is for sufficient data at a series of stress levels to permit application of various statistical treatments for their evaluation. The present paper provides data on more than 1000 specimens, and is a study of statistical treatments rather than a study of fatigue.

An ingot of commercial phosphor bronze containing 0.05% phosphorus and 5% tin was rolled to two lots 0.040 in. thick, one lot being hard temper and the other lot spring temper. Their properties corresponded to material cold rolled 37.4 and 60.5%, respectively.

The fatigue tests were all made on the same 24-specimen sheet metal fatigue machine. In order to permit conversion from deflection levels to stress levels which have a more general application in fatigue studies, a special experiment was run to estab-

lish the relationship between deflection and stress for these materials. The bending moment required to produce the given deflection was measured at six different levels using ten separate test specimens whose average thickness was equal to the average of the lot. The observed values of cycle life to failure up to  $10^8$  at zero mean stress are given for twelve deflection levels for the spring temper strip.

The observed distribution life values at several deflection levels are presented in the form of frequency histograms. The fact that even two successive runs appear to be different raises a question of how much variability is introduced by the test when specimens are tested one at a time as is usual on many types of fatigue testing machines.

Forty-eight observed values are not enough to determine what theoretical distribution best fits the data. Two of the histograms indicate a positive skewness, especially for small deflection values. Therefore a log-normal distribution was tried. The histograms of the logarithms of the number of cycles to failure are approximately symmetrical for deflections of 0.540 and 0.420 in., but the histogram for 0.300-in. deflection is skewed. Therefore, the extreme value distribution was plotted. There are two ultimate extreme value distributions; the distribution of minimums which corresponds to the weakest link theory and the distribution of maximums. The distribution of minimums is skewed to the left and the distribution of maximums is skewed to the right. Thus the extreme value distribution for maximums is appropriate for the present data which are skewed to the right. Except for the 0.300-in. deflection data, the log-normal lines and the extreme value curves differ only at the ends, corresponding to the tails of the distribution. Hun-

dreds of observations at each stress level would be necessary to decide which method of plotting gives a better fit.

When the data for the 0.300-in. deflection are plotted using the logarithms of the logarithms of cycle life, the histogram is still not symmetrical but it looks more compact than before. Comparison of the cumulative log-log-normal distribution with the log-extreme value distribution shows apparent difference only in the left tail, but the chi-square test for goodness of fit gives no indication that one method of plotting fits the data any better than the other.

Based on this study of fitting log-normal and extreme-value distributions to these data, two conclusions are drawn:

1. The log-normal distribution may be used for the finite life end of the deflection-cycle life curve, that is, the higher deflection levels.

2. The log-log-normal histogram may be used for the lower deflection levels at the infinite life end of the curve. The extreme value distribution does not appear to give any improvement in fit.

The plotted points on the deflection-cycle life curves can be converted to the conventional stress-cycle life, S-N, curves by use of the relationship for converting deflection to stress. For the intersections of the fitted lines and a constant value of cycle life such as  $10^6$ ,  $10^7$ , or  $10^8$ , the expected percentage of failures for a given deflection may be determined. The deflection levels are not close enough together to plot response curves for the percentage of specimens having cycle life less than a selected value. It is suggested that the use of response curves be investigated further. In an experiment designed for this type of analysis the deflection levels used would be grouped so that several fitted lines

# Los Alamos Secret Disclosed by Tr ATOMIC BOMBS DROP ON JA



## Deadliest Weapon World's History In Santa Fe Vic

Santa Fe learned officially today of the power of the bomb, with 2,500 times the power of the dynamite dropped on Germany, also lifts the community on the Pajarito Plateau. Santa Fe has ignored, except in whispers, the power of the atom.

## GRADUATE RESIDENCE CENTER ESTABLISHED AT LOS ALAMOS

### Bradbury Outlines

Dr. J. R. Doolittle, director of the Los Alamos Scientific Laboratory, outlined the plan for a graduate residence center at Los Alamos today. The center will provide a place for graduate students in the physical sciences and engineering, and will be under the direction of Dr. J. R. Doolittle.

Los Alamos Scientific Laboratory has completed arrangements with the University of New Mexico for the establishment of a Graduate Residence Center at Los Alamos. This program will provide the opportunity for employees and residents to meet all of the requirements for the master's degree in the physical sciences and engineering (including Nuclear Engineering) by attendance at evening classes. Some of these courses are taught by Laboratory personnel outstanding in their fields.

### Los Alamos

Los Alamos has been named as the site for a new atomic bomb. The bomb has been named 'Fat Man' and is expected to be dropped on Japan in the near future.

### Peterson Hails Result Of Atomic

Peterson, who has been working on the atomic bomb, has hailed the result of the atomic bomb as a great achievement.

### Hill Staffers Give Talks At Geneva

Hill staff members gave talks at Geneva regarding the atomic bomb and its potential.

In addition, there are extensive course offerings in the undergraduate and technician training fields for those wishing to pursue academic training related to their jobs or for their own development.

### National Citation AEC's Chief Visits Hill

The AEC's chief, Dr. J. R. Doolittle, has received a national citation for his work on the atomic bomb. He visited the Los Alamos Scientific Laboratory today.

### Strauss

Strauss, who has been working on the atomic bomb, has been named as the director of the Los Alamos Scientific Laboratory.

### 'Dedicated' Hillster Cauded By AEC Boss

The Hillster, who has been working on the atomic bomb, has been named as the director of the Los Alamos Scientific Laboratory.

Complete information about career opportunities and the academic training programs can be had by writing,

### Compasses Work

Compasses, which have been used in the atomic bomb, are now being used in other scientific experiments.

### Ultra-Fast Camera Developed On Hill

An ultra-fast camera has been developed at the Los Alamos Scientific Laboratory, which will be used in the atomic bomb.

Director of Scientific Personnel  
Division 1317

### Speculation Over H

Speculation over the H-bomb has been rampant in the Los Alamos Scientific Laboratory.

### Tests Indicate U.S. 'Hell Bomb' Now Successful Experiments at Eniwetok

Tests indicate that the U.S. 'Hell Bomb' is now successful. Successful experiments were conducted at Eniwetok.

### Report

A report has been filed regarding the atomic bomb and its potential.

### Incidents

Incidents have occurred at the Los Alamos Scientific Laboratory, which are being investigated.

### Now They Can Be Told Aloud, Those Stories of 'the Hill'

Now they can be told aloud, those stories of 'the Hill' which have been circulating for so long.

### Device Developed at Los Alamos Explodes Ground at Nevada Proving Grounds

A device developed at Los Alamos has exploded at the Nevada Proving Grounds.

### H-Bomb Disclosure Hill During Panel

The H-bomb was disclosed by Hill during a panel discussion.

### Tests Hint H-Bomb

Tests have hinted at the H-bomb, which is expected to be developed in the near future.

### Los Alamos Scientific Laboratory

The Los Alamos Scientific Laboratory is the center of atomic research in the United States.

### Third War Editor, Scientists Debate Preparation For New Chaos

The editor and scientists debated the preparation for a new chaos in the third war.

### Tests Hint H-Bomb

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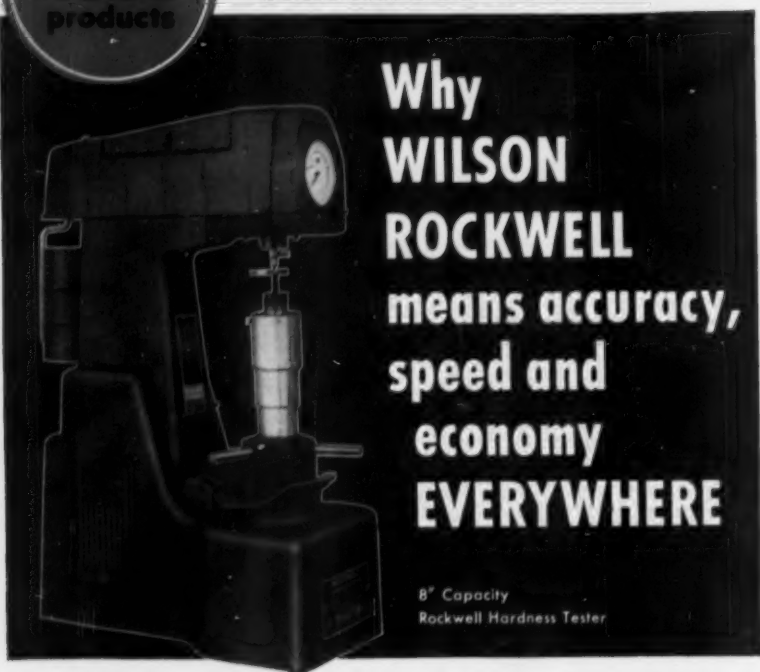
The Los Alamos Scientific Laboratory is the center of atomic research in the United States.

### Third War Editor, Scientists Debate Preparation For New Chaos

The editor and scientists debated the preparation for a new chaos in the third war.



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TO MEET  
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**REGULAR**  
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**SUPERFICIAL**  
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## Fatigue Data . . .

intersect the lines corresponding to the desired values of cycle life.

The results of this work suggest that in future experiments designed to give an S-N diagram for materials comparable to those tested, the number of specimens per deflection level should be considerably greater at the infinite life end of the curve than at the finite life end. The terms "finite life end" and "infinite life end" are used rather loosely to describe the parts of the S-N curves before and after the knee which is present at about  $10^6$  cycles to failure.

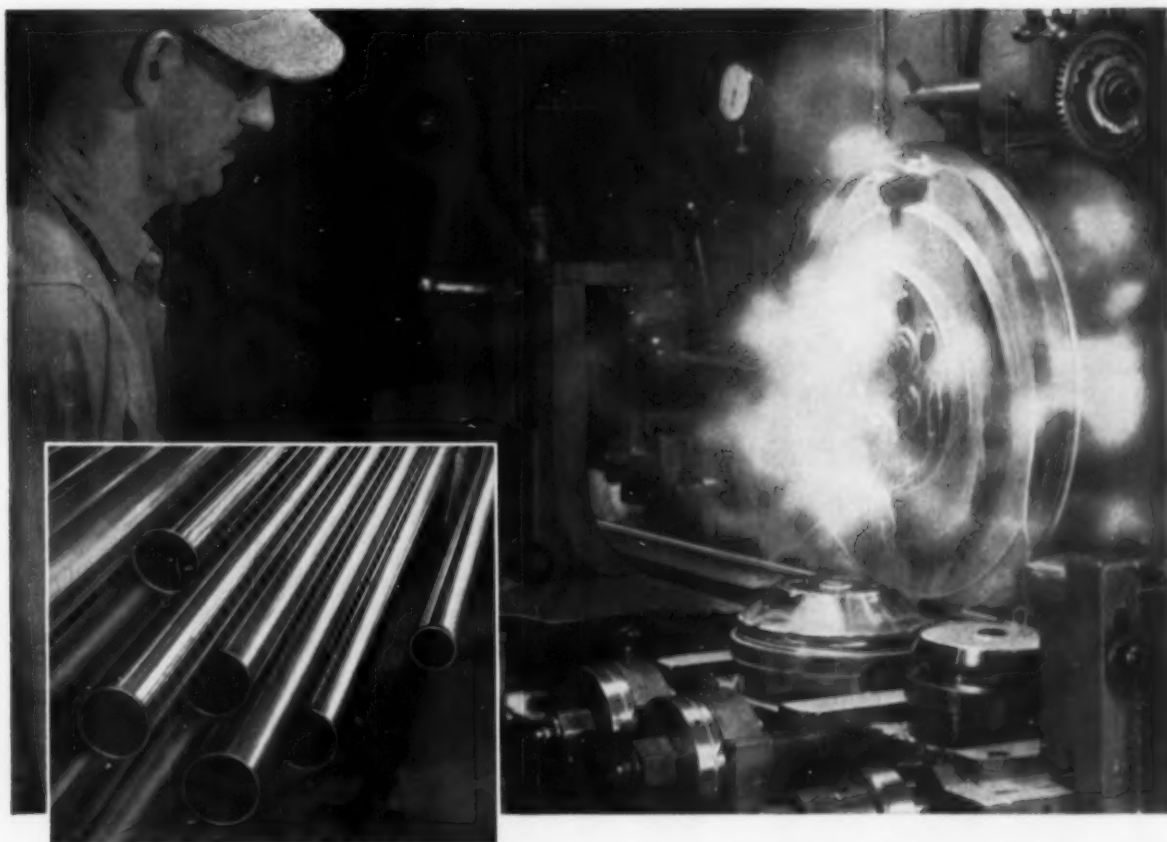
F. G. NORRIS

## Continuous Plating in Tandem Tanks

Digest of "Development and Manufacture of Electroformed Conductor for Telephone Drop Wire", by A. N. Gray and G. E. Murray, *Bell System Technical Journal*, Vol. 32, September 1953, p. 1099-1135.

**T**ELEPHONE drop wire, the black conductor connecting house and trunk lines, consists of a steel wire successively covered with copper, lead, brass and then cotton and neoprene insulation. Formerly, a cast copper-jacketed steel ingot was rolled and drawn to size to provide a wire having high strength and good conductivity. Coatings of lead and brass were electrodeposited on drawn copper-clad wire—the brass to provide an adherent surface for the neoprene rubber insulation, and the lead to prevent attack on the copper by sulphur in the rubber.

The successful deposition of the electroplates by two tandem lead and brass-plating machines at the Point Breeze Works of Western Electric Co. indicated the feasibility of adding a copper-plating section to the operation. Apparent advantages of such a process were that maximum strength of the steel core could be utilized since no compromise in physical properties would be required in rolling and drawing, as with the copper-jacketed wire. A uniform cross section could be secured which would provide continuous copper protection for the steel core against corrosion. Since the steel core wire would be a standard



## IN ELECTRIC-WELD PIPE AND TUBE MAKING

### Yoder leads the way to higher speeds and quality at lower cost

In the short period from 1938 to 1955, the production of electric welded pipe and tubing grew from 269,000 tons to over 3,000,000 tons. This phenomenal rate of growth—over two and one-half times faster than that of the pipe and tube making industry as a whole—to a large extent resulted from a series of important improvements in tube mill design, all introduced by Yoder.

First came the Yoder rotating welding transformer, in 1938. The economic and other benefits conferred by this epoch making innovation were further augmented by other technological advances scored by Yoder in the years that followed. The result was that electric-weld pipe and tube making became the child prodigy of the fast growing pipe and tube making industry.

Latest, and perhaps the greatest, of these developments is the cold forming and induction welding at high speeds

of aluminum, magnesium, brass, nickel, monel, and other non-ferrous metals and alloys. This process is especially economical for making light and medium gauge tubes in sizes up to 8 in. dia. More and more leading non-ferrous metal producers and fabricators are installing these mills.

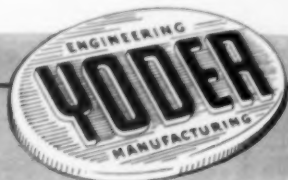
More complete information about this and other interesting Yoder developments in pipe and tube mill equipment may be had merely by asking for any of the following publications:

- ☐ Resistance-Weld Mills for making Steel Tubing up to 4" diameter.
- ☐ Induction-Weld Mills for making Non-ferrous Tubing.
- ☐ Resistance-Weld Mills for Steel Pipe up to 24" diameter.

#### THE YODER COMPANY

5595 Welworth Avenue

Cleveland 2, Ohio

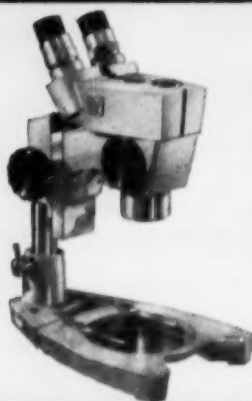
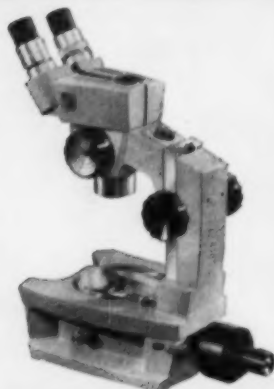


**PIPE AND TUBE MILLS—Electric Weld  
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Completely new series of  
**STEREOSCOPIC MICROSCOPES**

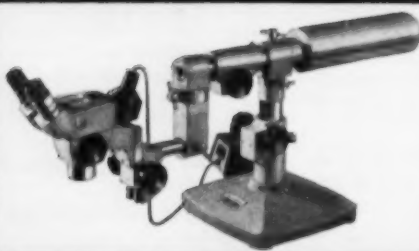


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## Continuous Plating . . .

commercial item available from a number of manufacturers, alternate sources would be available to assure continuity of supply.

By starting with a stronger steel wire of uniform and circular cross section and applying a uniform copper electroplate, the desired physical and electrical requirements could be met by a conductor 0.0025 in. smaller in diameter. This reduction indicated a saving of a half-million pounds of copper a year and a combined saving of steel, copper, rubber, cotton and neoprene of a million pounds a year. Combined savings to the Bell System operating companies and Western Electric Co. were estimated at better than a million dollars a year.

Commercial improved plow-steel wire 0.0336 in. in diameter is used for the core material of the drop wire. Twenty-five strands fed from 450-lb. reels pass through the plating machine in parallel at 100 ft. per min. After suitable cleaning, approximately 0.0025 in. of copper plus a thin plate of lead and brass are electrolytically deposited on the wire. To apply this deposit requires nine different electrolytes, approximately 80,000 amp. at 5 v., a 600-ft. machine and a wire span from supply to take-up of 850 ft.

The plating section of the machine is essentially a long trough containing plating cells alternating with contact rolls. The electrolytes are pumped into the plating cell through which the wire passes, cascade into return troughs, flow back to reservoirs and are continuously recirculated. The contact rolls position and propel the wires through the machine and serve as cathode contacts. The wire, in passing from one electrolyte to another, travels through washing and wiping facilities mounted in the troughs to prevent contamination of electrolytes and reduce dragout.

The only deviation from the steel mills' standards regarding core wire is the method of packaging. Instead of the usual 250-lb. bundles, Western receives the wire on 450-lb. reels which are more economical to handle on a continuous plating machine. Each of the 25 wire channels on the electroforming machines is provided with a dual supply stand holding

Case No. 42

Kemp Immersion Heating  
Gets Top Results  
for Signode Steel  
Strapping Company



## How Signode Steel Strapping Co. tempers 650 feet of steel strap every minute

At the Signode plant in Sparrows Point, Md., turning out up to a thousand miles of steel strap daily calls for fast, efficient production line techniques. One highly important phase in the final processing is the tempering bath. Here, Signode called on Kemp Engineers to supply the 15 ton, gas-operated Immersion Melting Pot shown above. Now steel strap is uniformly tempered at the rate of 650 feet per minute.

### Kemp Offers More Advantages

By installing Kemp Immersion Heating, Signode benefits in many ways. Unlike underfired pots, Kemp pots are *not* subject to *periodic* and expensive shutdowns . . . won't crack or break. They operate con-

tinuously at maximum heating efficiency with a *substantial* savings in fuel costs. Offer a greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures. At the same time, this Kemp unit enables Signode to eliminate costly temperature override and open flame fire hazards.

### Let Kemp Solve Your Problems

These same advantages apply to all types of melting or heating operations. Whether you are engaged in tempering, annealing, descaling, coating, etc., you can rely on Kemp Immersion Heating. Why not find out how Kemp Engineers can help you, save you money?



This 10 ton oval pot is typical of the many Kemp installations now in use. Features Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste . . . without tinkering. One-pipe air and fuel feed reduces installation costs, simplifies maintenance.

For more complete facts and technical information, write for Bulletin H-11 to C. M. KEMP MFG. CO., 405 East Oliver St., Baltimore 2, Maryland.

# KEMP OF BALTIMORE



## IMMERSION MELTING POTS

CARBURETORS • BURNERS • FIRE CHECKS  
ATMOSPHERE & INERT GAS GENERATORS  
ADSORPTIVE DRYERS • SINGING EQUIPMENT

## Continuous Plating . . .

two reels, one the pay-off and the other a stand-by. The inner end of the supply wire paying off is spliced to the outer end of the stand-by.

The wire tensions developed by the take-up spool drives are controlled within  $\frac{1}{2}\%$  over the adjustable wire speed range of 80 to 120 ft. per min. If tensions are too low, the wire

may lose contact on the rolls or sag or weave in the plating cells enough to disturb the spacing between the wire cathode and the anode bed in the cell, or stall or hesitate long enough to burn through at a contact roll. If tensions are too high, the wire causes excessive wear of the contact rolls and bruises or scrapes the relatively soft thin lead and brass plate.

The first bath is a hot alkaline

cleaner for removing oil, drawing compound and dirt. This section contains eight cells. The wire is anodic, with the body of the cells the cathode. The current density of 100 amp. per sq.-ft. applied to the wires causes an ebullition of gas which materially helps the cleaning operation. The alkali cleaner section is followed by a steam wiper.

The sulphuric acid pickle section removes scale and rust and imparts a slight etch to promote adhesion of the subsequent copper deposit. An inhibitor is added to prevent solution of an excess of iron which would result in a heavy carbon smut on the surface of the conductor. Following the pickle is an air wiper, a water wash and a steam wiper.

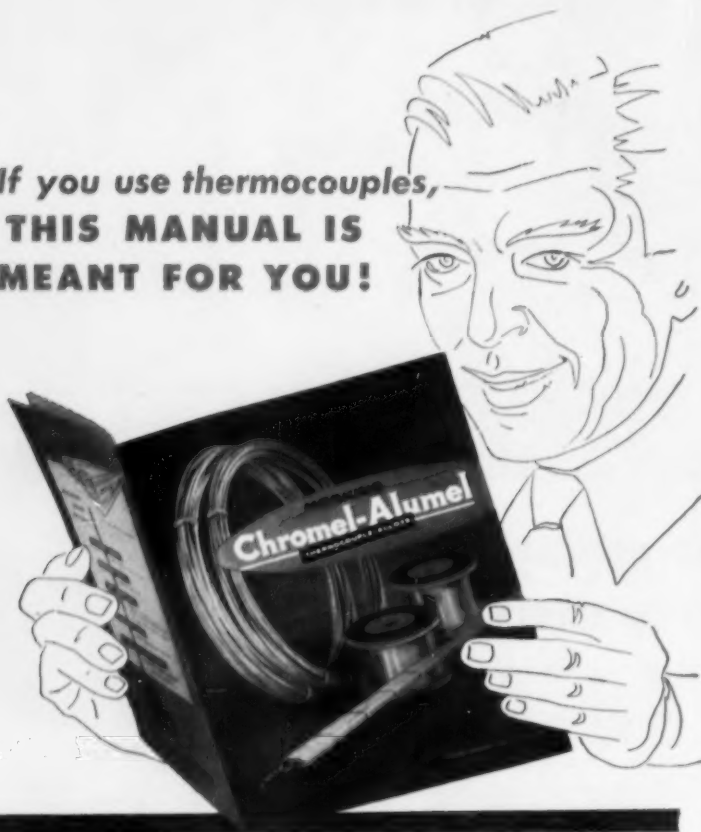
The initial coating is a "cyanide flash", a thin layer of copper from a copper cyanide solution designed to give smooth deposit. There are five plating cells from which the copper is deposited at a relatively low current density. The wire is cathodic.

Following the copper cyanide flash the wire passes directly to the copper cyanide plating solution where 0.0001 in. of copper is deposited at a high current density. Seventeen plating cells in which copper shot resting directly on the steel cell bottoms forms the anode surface are needed to deposit the required thickness. This section is followed by a dragout recovery unit, a water wash and a steam wiper.

The production plating section has 58 plating cells alternating with 57 copper contact rolls. Copper plates in the bottoms of the cells distribute current to a bed of copper shot which forms the active anode surface. A relatively large number of cells is required because of the magnitude of the total plating currents involved. Several thousand amperes are required to deposit copper at the rate of 0.001 in. per min; however, instantaneous fusion of the steel wire would result if this current were forced through it at one time. The repeated passage of smaller currents, which will not overheat the wire, will deposit the same amount of copper.

The wires then pass into a dragout recovery cell where they are washed by the make-up water, through the air wiper and a water wash before entering the heat treat section. The heat treatment has two functions; to anneal the deposited

**If you use thermocouples,  
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*Whether you gun it...*



*or slap-trowel it...*



**Johns-Manville BLAZECRETE**

**BUILDS BETTER REFRACTORY LININGS**

## **Continuous Plating . . .**

copper and to strain relieve the hard drawn steel core wire sufficiently to increase its elongation to between 3 and 7%. Current is passed through each wire to heat it. The heated wires pass through a water wash, which serves as a quench, and then through a steam wiper.

Next is the cleaning in hydrofluosilicic acid to remove any oxide formed in the heat treatment. The lead electroplating section consists of four cells. The electrolyte is lead fluosilicate. Lead sheets in the bottom of the cells covered with lead shot form the anodes.

The brass plating section applies the final deposit to the wire. Its function is to provide a coating which will unite chemically with the insulating compound with sufficient adhesion that the load from the drop wire clamps used to support the wire in service will not cause the insulation to slip on the conductors. The composition of the deposited brass is controlled between very close limits to obtain the desired adhesion between conductor and insulating compound. The electrolyte contains copper and zinc cyanide. There are four cells in the brass electroplating section. The anode material is a mixture of copper and brass punchings which rest on the cell bottoms.

JOHN PARINA, JR.

## **Plastic Laps for Metallographic Specimens**

Digest of "Plastic Laps for the Preparation of Specimens for Metallographic Examination", by V. J. Haddrell, E. C. Sykes and B. W. Mott, *Journal of the Institute of Metals*, Vol. 84, January 1956, p. 112-114.

IT IS DIFFICULT to prepare satisfactory metallographic specimens from porous powder compacts, materials containing a large number of nonmetallic inclusions or polyphase alloys with marked differences in hardness, by conventional mechanical and electrolytic techniques. The usual methods include diamond dust, lead and wax laps and attack-polishing techniques, all of which have some disadvantages. A suggested

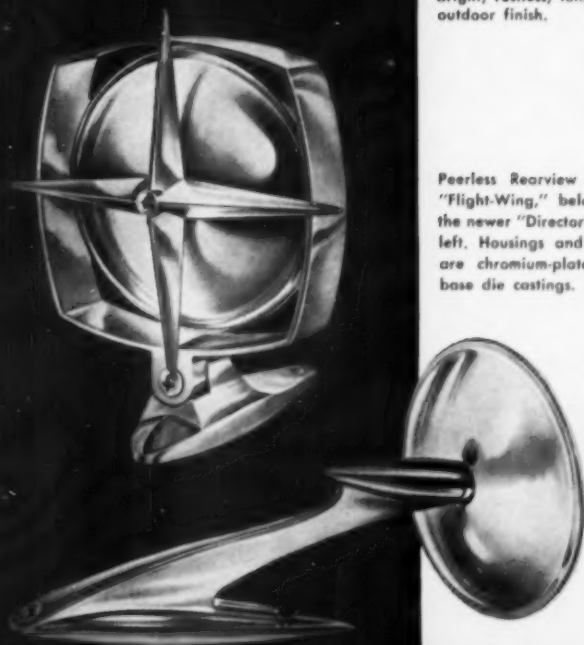
Bob Rossi, Chief Engineer, tells  
Roy Johnson, Plant Manager

"We switched to **Formbrite**

—and saved 12 cents apiece!"



.032" gage 70-30 Formbrite is used for this 4½" diameter rearview mirror head shown full size. Strip is 5½" wide supplied in heavy coils for long press runs. Copper, nickel and chromium plating on a solid brass base provides a bright, rustless, long-lasting outdoor finish.



Peerless Rearview Mirrors. "Flight-Wing," below, and the newer "Director" model, left. Housings and mounts are chromium-plated zinc-base die castings.

This easy-to-polish, superfine-grain drawing brass has been slashing finishing costs in plant after plant, on all kinds of jobs. Now Peerless Accessories Co., of Mount Holly, N. J., reports:

"To our line of lighting and safety automotive accessories, we've recently added two rearview mirror assemblies. We had been using regular drawing brass for the dished head until your representative persuaded us to try Formbrite. Here are the results, based on a very careful cost study:

**Finishing procedure using regular drawing brass**

- 1) Grease grinding or "cutting"
- 2) Buffing
- 3) Copper strike
- 4) Nickel plate (.00045")
- 5) Buffing nickel
- 6) Chromium plate

Cost 27¢ each

**Present procedure using Formbrite®**

- Not necessary with Formbrite  
Light buff  
Copper strike  
Bright nickel plate (.0003")\*  
Not necessary  
Chromium plate

Cost 15¢ each

"That's a saving of 12 cents apiece. Multiply it by 3,000 to 4,000 a day and it becomes important money!"

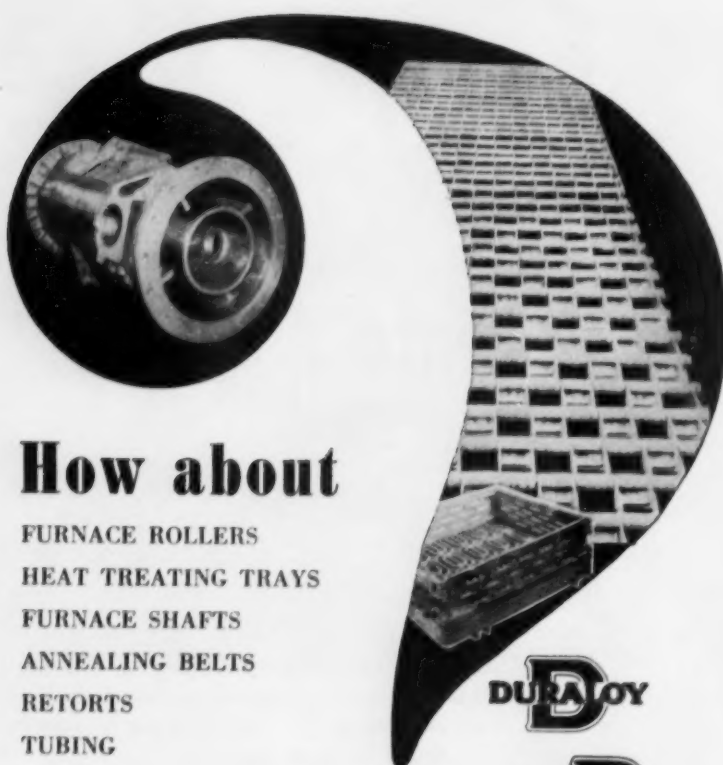
\*Formbrite's superfine grain made possible a lighter but equally serviceable plate of bright nickel

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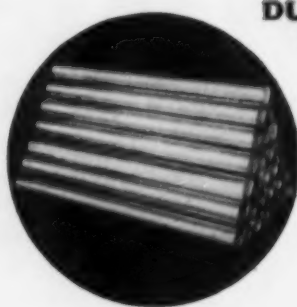
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## Plastic Laps . . .

method is the use of plastic laps similar to those used on ceramics.

The first experimental plastic laps were made from dental acrylic resin with carbide, alumina or rouge as the abrasive. They were unsatisfactory because they were too porous and brittle and cutting action was irregular. Laps of soft polythene were prepared in a 1½-in. diameter metallographic mounting press and used in an automatic polishing machine. The quality of the laps was greatly influenced by the molding pressure and curing temperature. The size and composition of the abrasive determined the molding conditions. Finer abrasives required lower pressures and lower curing temperatures.

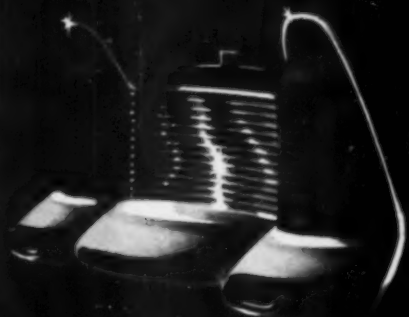
The speed of rotation of the lap and the specimen pressure are not critical, although the pressure is usually greater than in mechanical polishing. Water is employed to lubricate the lap surface; fine abrasives require only a damp surface while coarser abrasives require liberal amounts of water.

The flatness of the specimens after polishing is comparable to that obtained using diamond dust. The amount of cold working of the surface is very small. The coarse abrasive laps wear well and require little truing. The fine abrasive laps require no truing even after six months of continual use.

Polythene laps using diamond dust as the abrasive have also been prepared. The diamond dust is in a layer about 0.004 in. thick. Surfaces produced with this lap are noticeably flatter than those obtained with diamond dust on a cloth wheel.

Since polythene is resistant to acids and solvents, plastic laps have been applied to attack-polishing with an automatic polishing machine. Laps made from iron oxide and polythene produce scratch-free polishes on uranium alloys when a mixture of three parts nitric acid and two parts hydrofluoric acid is used. The plastic laps deteriorate when left in the solution. To overcome this difficulty a Terylene cloth fabric may be used to cover the plastic. This gives excellent results when used with a suspension of alumina or rouge in the acid mixture.

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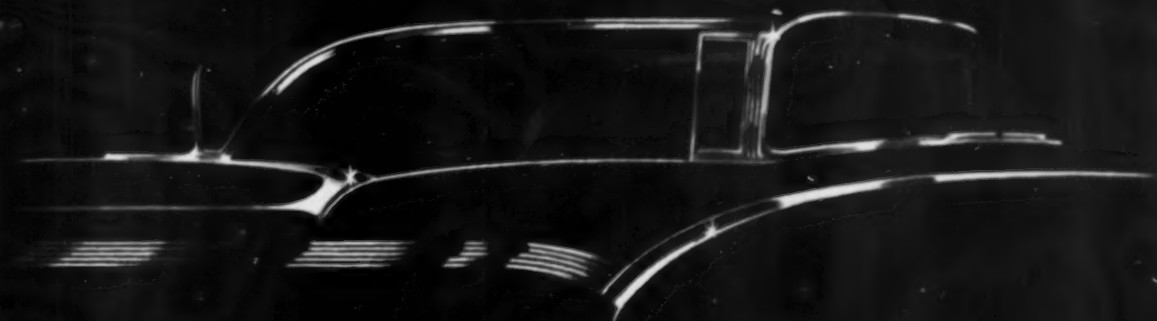
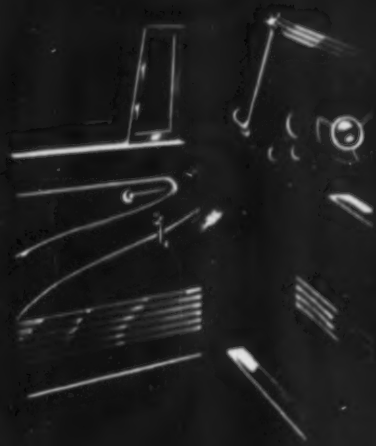
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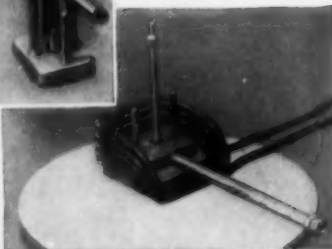
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## Russian Study of Diffusion

Digest of "Diffusion Fronts in Commercial Iron", by V. I. Arkharov, K. A. Efremova, S. I. Ivanovskaia, A. K. Shtol'ts and B. A. Iunikov, *Doklady Akademii Nauk SSSR*, Vol. 89, March 1953, p. 269-270.

THE DIFFUSION of nickel, palladium, copper and chromium into iron was studied by stacking thin strips of the metals alternately in the form of a sandwich, annealing in hydrogen to remove the surface oxide films and hot rolling together. The sandwich was then annealed at a selected temperature. After the annealing treatment a cross section of the specimen was polished and etched and the contour of the diffusion interface studied.

Both chromium and aluminum gave a uniformly wide continuous diffusion zone with an even front indicating that these elements diffused at the same rate in the body of the grain and in the grain boundaries. The diffusion fronts of nickel, palladium and copper showed projections along the intercrystalline boundaries, indicating a faster rate of diffusion of these metals along the grain boundaries of the iron. Arkharov also found this effect in studying the diffusion of silver into polycrystalline copper containing antimony.

A study of the nickel-iron diffusion interface showed that the nickel forms a closed network of loops around the grain boundaries of the iron. Eventually these loops become filled with nickel which diffuses along the main diffusion front and from the circumference of the loops into the body of the grains.

The rate of grain-boundary diffusion into iron is retarded by small additions of other elements. The diffusion of nickel, for example, is slowed down by additions of 0.20% titanium, 0.12% columbium, 0.004% boron or 0.20% molybdenum. The molybdenum is effective enough to eliminate completely the grain-boundary projections in the diffusion front of nickel into iron. It is assumed that the titanium, columbium, molybdenum and boron are concentrated at the grain boundaries, thus blocking the diffusion of nickel. A similar effect was found by Arkharov when studying the diffusion of

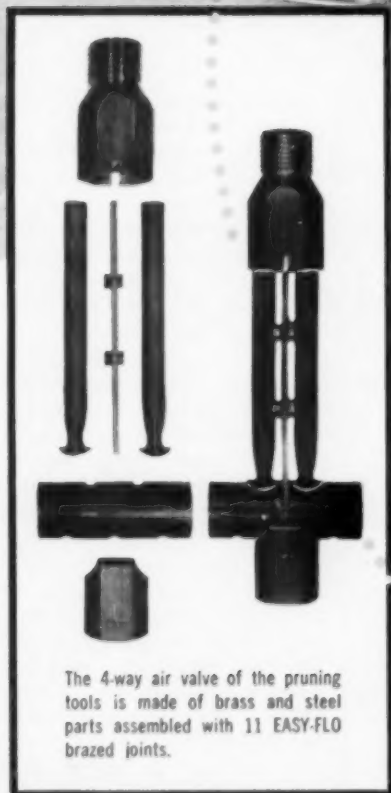
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## Diffusion . . .

silver into copper in which small additions of beryllium slowed down the grain-boundary diffusion rate.

Interesting results were obtained by the authors in experiments on the diffusion of silver into an iron-palladium alloy. Silver and iron are mutually insoluble at all temperatures so that the diffusion rate of silver into pure iron is infinitesimally

slow. However, when silver is allowed to diffuse into an iron-palladium alloy (0.2 to 1.0% palladium) at a temperature of 1725° F., marked diffusion is visible. At the silver-iron interphase boundary, a thin network which assumes a light color on etching is observed. The network delineates the gamma-iron grain boundaries which are present at the annealing temperature and which, the authors claim, contain a high concentration of palladium.

Thus, the presence of a second element has increased the diffusion rate of silver into iron.

This effect was not found when silver was allowed to diffuse into an iron-copper alloy. In this alloy an even diffusion front was formed; however, the authors had shown that if copper is allowed to diffuse into iron it diffuses along the intercrystalline boundaries. The fact that silver did not follow this path, which was expected to contain a high concentration of copper, is explained by assuming that the accelerated diffusion of copper along the grain boundaries of iron was due to the presence of small quantities of impurities in these regions. The copper, when added as an alloying element, did not segregate to the grain-boundary regions.

W. A. MORGAN

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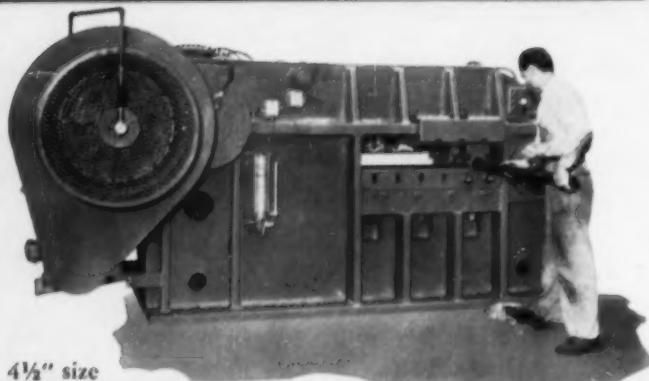
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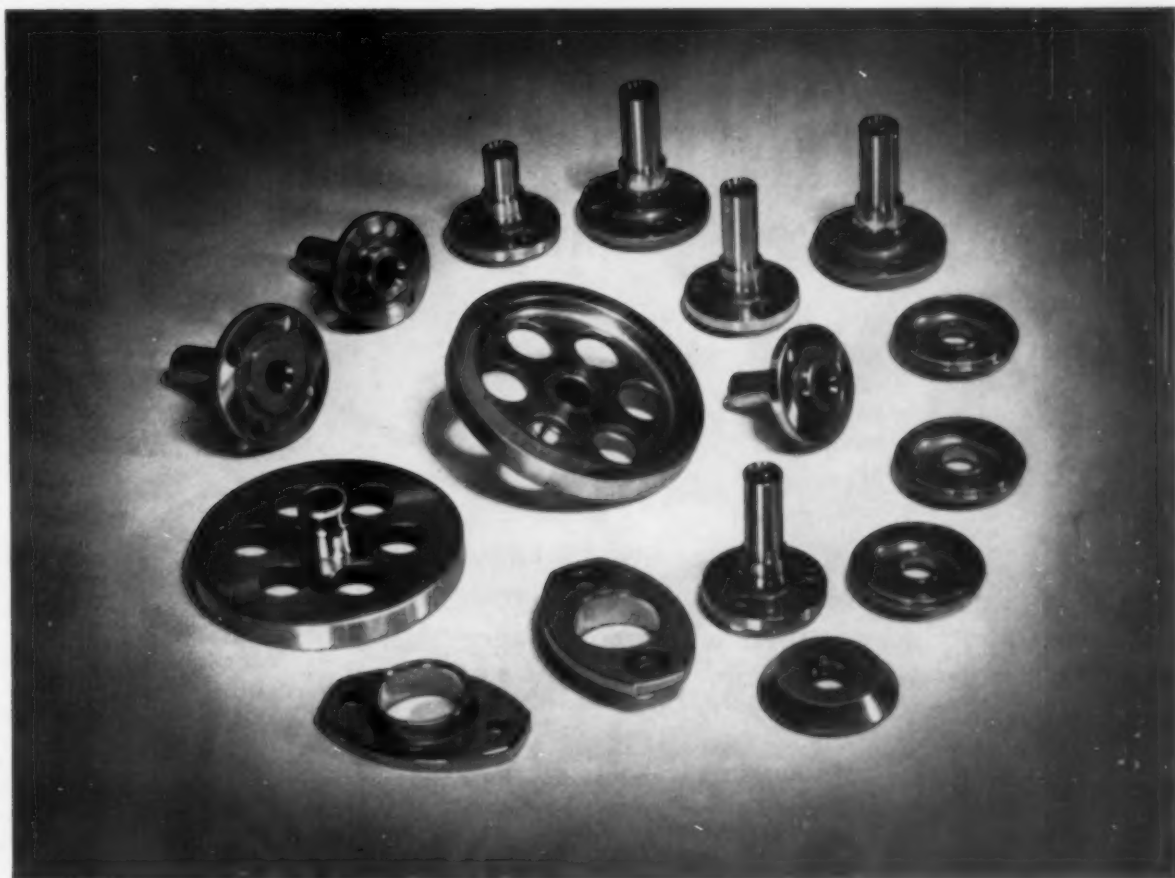
## Effects of Cutting Fluid Composition

Digest of "Method of Applying Cutting Fluids", by M. C. Shaw and P. A. Smith, American Society of Tool Engineers, Research Report No. 3, March 1956, 21 p.

**T**OOL LIFE can be extended and machined finishes improved if the friction force acting on the face of the tool can be reduced by the application of a boundary lubricant. The latter term means any solid, liquid or gas which can penetrate the space between chip and tool face to form a film which has low shear strength relative to that of the chip.

Such a boundary film must become very strongly attached to the chip or it will be pushed aside as the chip slides across the tool face under enormous pressure. The only bonding forces of sufficient strength are those which hold chemical compounds together; hence the protective film that forms on the chip surface is a result of chemical bonding or reaction between the boundary lubricant and the clean metal surface. The lubricants used in metalworking operations behave in an entirely different way from the fluid-film-forming lubricants commonly applied to journal bearings and machinery.

One way to provide the low-shear-strength film is that employed in free-machining steels and cast irons. Inclusions of sulphur, lead, selenium or graphite in the metal are squeezed



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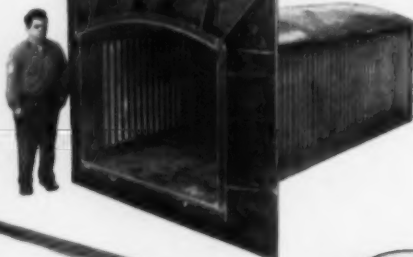


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## Cutting Fluids . . .

from the chip and spread over the surface to give the desired boundary layer. Free-machining additives are effective in reducing friction at high machining speeds. Sulphur and other solid lubricants also have been incorporated in grinding wheels to provide a source of low-shear-strength film-forming material close to where it is needed.

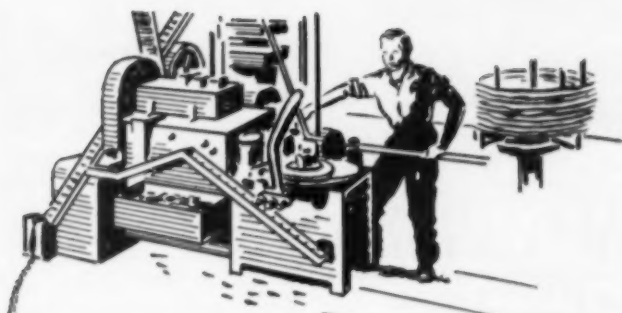
Cooling action of cutting fluids has an important effect on tool life, particularly in high-speed machining operations where considerable heat is generated. In fact, the major role of a cutting fluid at speeds above 200 ft. per min. is cooling, according to tests performed with fluids in the form of both floods of liquids and as mists. At 250 ft. per min. commercial water-base fluids applied in liquid form were somewhat better than water due to slight boundary film action. However, at 400 ft. per min. the action proved to be entirely one of cooling, and water is as good as any of the commercial preparations.

Apparently a large amount of evaporative cooling develops when a water mist is used and the amount decreases rapidly when additions are made to the water. If a water mist appears impractical because of rusting, a small amount of an inhibitor will give better results at high cutting speeds than an oily additive which interferes with heat transfer between tool, work chip and water droplets.

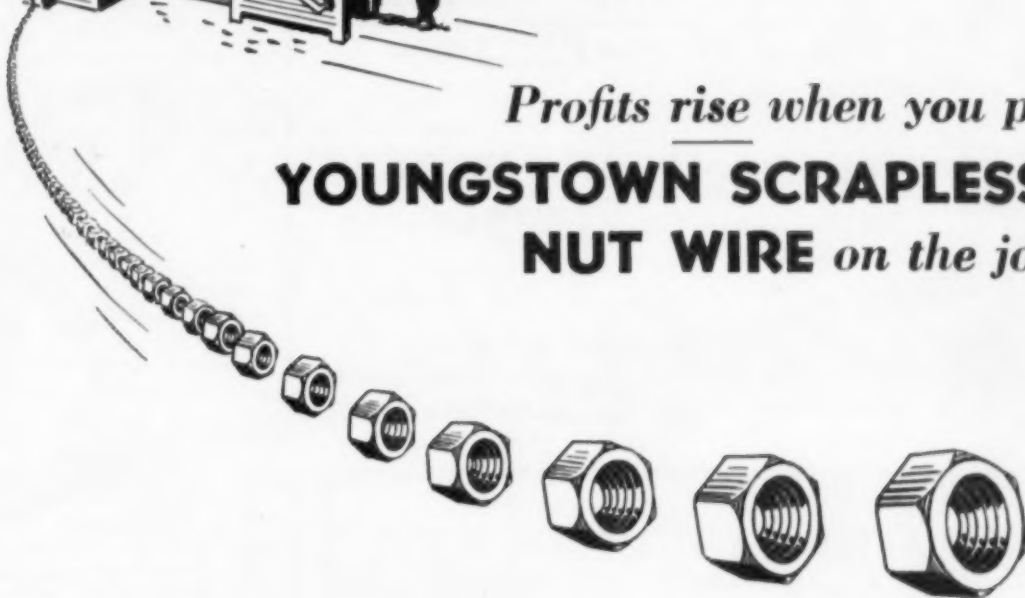
The best angle or direction in which to apply fluid in the form of either a flood or mist is along the clearance face of the tool, although this may require covering the machine during high-speed turning to avoid spraying the operator. Application along the back of the chip is an alternate possibility but the fluid should never be directed along the tool face.

In the final analysis, there is much more difference in tool life caused by metallurgical variations from heat to heat of steel than there is attributable to differences in cutting fluids.

Gaseous lubricants are attractive when their penetration effect is considered. Operations performed dry actually are carried out using air as a cutting fluid. Although its presence is usually taken for granted, air is an important and effective boundary lubricant. The difficulty is that all



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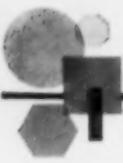
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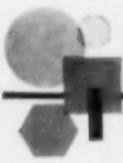
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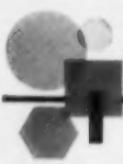
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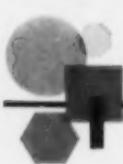
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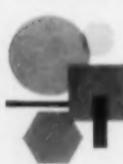
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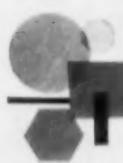
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## Cutting Fluids . . .

gases have relatively poor cooling capacity in contrast with liquids. Refrigeration of air has given improved tool life in some tests.

Both carbon dioxide gas and nitrogen have been tried as cutting "fluids". In one instance, nitrogen gave a 240% increase over air on tool life. The action is presumed to be some form of positive boundary lubrication effect. In the same series of tests, the increase with carbon dioxide was only 150% over air.

Mist lubrication, in which small droplets of liquid are distributed in a large volume of air, has been applied to lubricate high-speed ball bearings for about 25 years. Recently, a similar scheme involving a larger concentration of liquid and coarser particle size has been adopted in some machine shops to advantage. The large surface-to-volume ratio for each particle of liquid provides rapid vaporization, an important step that must precede penetration at the chip-tool interface. A material of low boiling point and high latent heat of vaporization gives the best results. Water is ideal in this respect, while oils are much less satisfactory.

In studying the influence of cutting fluids on surface finish, profilometer values measured in a circumferential direction on a turned bar are of little value. A better method is to pass a soft lead pencil across the surface under controlled conditions of pressure and rotation and then to measure with the aid of a micrometer the volume of lead worn away. This gives a factor proportional to the volume of roughness particles per unit of finished surface. This lead pencil wear technique, in conjunction with an analog tool rotated at 90° from its conventional position, provides a means of comparing the ability of a group of fluids to produce a good finish. A speed of 100 ft. per min. is a convenient rate for such comparisons.

In all tests, surface roughness was found to have a sharp maximum at 50 ft. per min., and the effect of speed upon surface finish is far greater than that due to differences between the water-base fluids tested in the vicinity of 50 ft. per min. Water is not a good lubricant when finish is a primary factor. A. H. ALLEN

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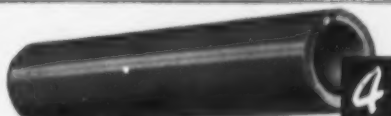
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Leading automotive companies need and use TOCCO hardened axle shafts to handle higher horsepower. Better, yet cheaper—savings of \$375.00 per day. Less machining costs, lower priced material, increased production, and a plus in quality—200% greater torsional life.



3

Kearney & Trecker Corp. reduced the cost of hardening this milling machine part from \$1.57 to 10¢ apiece. In addition TOCCO made possible a switch from alloy to S.A.E. 1045 steel—saving another 11¢ per piece in material cost. Kearney & Trecker hardens 140 different parts on one TOCCO unit.



4

Thompson Products Ltd. boosted production of these automotive wrist pins from 500 to 1200 per hour when they switched to TOCCO-hardening. Costs fell from \$5.45 to \$3.25 per hundred parts—a savings of 2¢ per pin, \$26.40 per production hour.



5

Mechanics Universal Joint Division of Borg-Warner reports a 69% savings in the hardening of stub ends for propeller shafts. TOCCO also upped production from 35 to 112 parts per hour—over three times as fast as conventional heating methods.

Lima-Hamilton Corporation adopted TOCCO for hardening this shifting lever. Results: a savings of 4¢ per piece—\$25 per production hour. TOCCO costs only 17% of former heating method. This is only 1 of 139 parts TOCCO-hardened by Lima-Hamilton Corp. All show savings over usual heating methods.



6

7

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Conventional chilled iron abrasives break down rapidly,  cause high maintenance costs ; annealed iron abrasives don't have the cutting efficiency, tend to leave graphite deposits . The choice is determined by the side of the abrasive fence you are on ; your own blastcleaning requirements are the deciding factor. But here's a point: Controlled T "chilled" and Permabrasive "annealed" shot and grit are engineered  to overcome the respective disadvantages of chilled iron and annealed iron abrasives. If you must use chilled iron abrasives, Controlled "T" cleans as fast as any chilled iron abrasive , yet lasts far longer, is easier on equipment. If you can use annealed iron abrasives, Permabrasive cleans fast, leaves a clean surface  and is the most durable of all annealed iron abrasives. We'll guarantee a savings\* in writing , and give you a check to  produce the guaranteed savings if we fail.

\*10% in the case of Permabrasive, 15% in the case of Controlled T

## WRITE FOR:

- ☐ "A Primer on the Use of Shot and Grit"
- ☐ "It's Triplets" (A Story of Palletizing)
- ☐ "Tired of Making Tests?"



THE NATIONAL METAL ABRASIVE COMPANY  
Cleveland, Ohio  
THE WESTERN METAL ABRASIVES COMPANY  
Chicago Heights, Illinois  
SOLD EXCLUSIVELY BY  
**HICKMAN, WILLIAMS & CO.**  
(INCORPORATED)

CHICAGO • DETROIT • CINCINNATI • ST. LOUIS • NEW YORK  
CLEVELAND • PHILADELPHIA • PITTSBURGH • INDIANAPOLIS

## French Anodizing Practice

Digest of "Aluminum Alloys for Anodic Processing", by J. Herenguel; Joint American Metallurgical Societies Meeting in France, June 1955, 8 p.

IN FRANCE anodizing is used to protect aluminum from corrosion, produce decorative surfaces on structural items and bright finishes for jewelry and lamps. Surface imperfections of the base alloy affect the anodized finish because the alumina coat is translucent. Since the oxide film is resistant to electricity skin holes and other superficial defects are often enlarged. Reticulation and spottiness of the coating may result from uneven alloy composition.

Alloys containing over 5% copper or 8 to 12% silicon are unsuitable for anodic oxidation protection against corrosion. Even with 4% copper there is too much local attack, and alloys with 2% copper are difficult to protect adequately in this way. Dark and spotty anodic films may form on commercially pure aluminum although pure aluminum takes good anodic films. Pressure castings are more suitable for anodic protection than sand castings because of better surfaces.

Good decorative finishes can be produced only on castings containing titanium plus 2 to 4% magnesium or 2 to 4% zinc, and on wrought alloys containing 0.2% silicon, 1 to 3% magnesium or 4% zinc. To avoid reticulation, mottle or other surface defects, hot worked parts should be pickled and cold finished with dust-free polished rolls, handled and stored on leather or wood and protected by plastic coverings till final fabrication. Mechanical polishing should then be unnecessary. Drawn products may have to be machined and polished.

For bright-finished jewelry and mirrors 99.9% aluminum is normally used so that the oxide film is translucent even though it is 8 to 15 microns thick. Alloys containing up to 5% magnesium may also be used. The composition must be uniform and fabrication must be carefully controlled to give a perfectly homogeneous structure and smooth surface. Plastic film protection is essential after finishing.

G. F. COMSTOCK

Metal Progress

# Bulletin Board...

The Buyers Guide  
For Metals Engineers

**CIRC-AIR**

**HEAT TREATING  
FURNACES**

for  
Every Heat Treating  
Process

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**CONTROLLED  
ATMOSPHERES**

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**DIRECT FIRED**

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**CIRC-AIR DRAW  
FURNACES**

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**CIRC-AIR NICARB  
(CARBONITRIDING)**

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*Specially Engineered  
for  
Your Particular Needs*

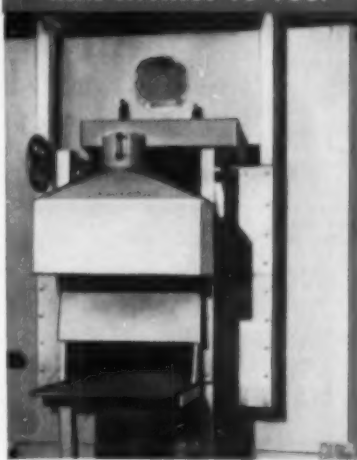
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**GAS • OIL • ELECTRIC**

**INDUSTRIAL  
HEATING EQUIPMENT  
COMPANY**

1375 Fremont Pl. • Detroit 7, Mich.  
Manufacturers and Distributors of Furnaces Since 1917

LIST NO. 19 ON INFO-COUPON PAGE 169

**GOOD USED EQUIPMENT AT  
REAL SAVINGS TO YOU!**



Electric Furnace Co. Conveyorized Brazing or Bright  
Annealing with 22" Cooling and Eas. Gun Inside Work  
Dimensions: 18" Wide x 120" Long x 10" Clear —  
2100° F 100KW 230V  
Cost \$30,000. Our Price \$9,800.

- We Buy — Sell — Lease — Rent!
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- Immediate Delivery!
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- Warehouses in Major Cities.

PLEASE SEND YOUR REQUIREMENTS OR  
CALL COLLECT TOWNSEND 8-8450

**METAL TREATING  
EQUIPMENT EXCHANGE, INC.**  
9825 GREELEY ROAD  
DETROIT 11, MICHIGAN

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## Upton

.... OFFERS  
the most advanced  
Salt Bath Furnaces

FOR ....

**BATCH**

**CONVEYORIZED**

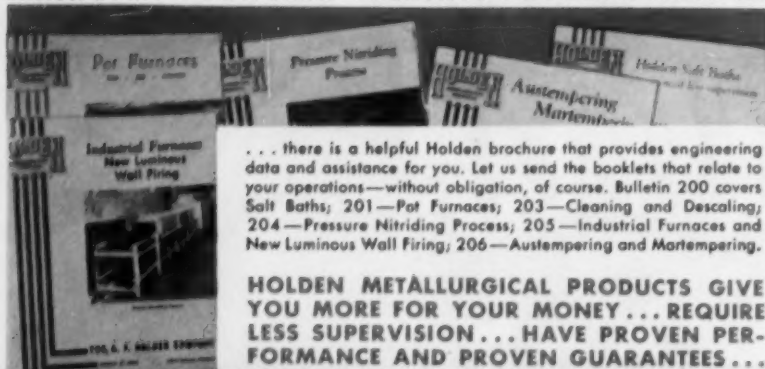
**ALUMINUM  
BRAZING**

with continuing  
graphite electrodes

**UPTON ELECTRIC FURNACE CO.**  
30435 Groesbeck  
Roseville, Michigan  
Phone: Prescott 1-1200

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## WHATEVER YOUR HEAT TREATING PROBLEM MAY BE



... there is a helpful Holden brochure that provides engineering data and assistance for you. Let us send the booklets that relate to your operations—without obligation, of course. Bulletin 200 covers Salt Baths; 201—Pot Furnaces; 203—Cleaning and Descaling; 204—Pressure Nitriding Process; 205—Industrial Furnaces and New Luminous Wall Firing; 206—Austenitizing and Martempering.

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(MADISON 1-9182)

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## SWIFT CASE 560 LIQUID CARBURIZER

FOR... A tougher, more durable case

... Fast, free washing

... Maximum versatility

Completely water soluble—free washing even after oil quenching—higher hardness with maximum toughness and surprising production economy!

Send today for technical data sheets

**Swift**  
INDUSTRIAL CHEMICAL CO.  
Canton Connecticut

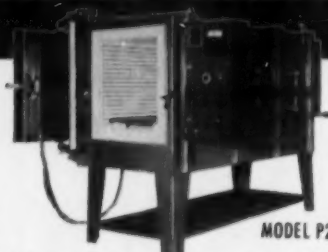
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**dyna-trol**

## ELECTRIC FURNACES

MODEL NO.	FIRING CHAMBER (H.W.D.)	PRICE (200" to 3000")	PRICE (400" to 2300")
P46	4 1/2" x 4 1/2" x 6"	\$90.00	\$110.00
P79	6" x 6" x 9"	\$205.00	\$225.00
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P124	14" x 14" x 14"	\$525.00	\$603.25
P124	12" x 12" x 24"	\$715.00	\$822.25
P818	18" x 18" x 18"	\$775.00	\$887.50
P136	18" x 18" x 36"	\$1125.00	\$1312.50

Automatic Controls Available on all Models



MODEL P2472-1

- Infinite zone temperature control.
- Zone temperature indication by Pyrometer Selector Switch.
- Automatic hold and cut-off instrument available.
- Patented element holders.
- Infinite variety of time-temperature curves obtainable.
- Rugged construction. Highest quality insulation used.

OVER 40 STANDARD MODELS • WRITE FOR LITERATURE



MODEL P-79

**L & L**

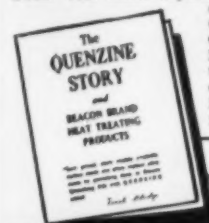
INDUSTRIAL DIVISION  
**MANUFACTURING CO.**  
CHESTER 77, PA.

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**FREE**

## the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to...



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3401 W. 140th St., Cleveland 11, Ohio

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for nearly a quarter of a century

## STANWOOD HAS DESIGNED AND FABRICATED HEAT TREATING EQUIPMENT!

We can say with pride that no organization has had more experience than Stanwood—and few have had as much experience—in producing baskets, trays, crates, fixtures, reforming carburizing boxes, and other devices for handling parts through heat treating quenching and kindred operations. Stanwood engineers understand the proper application of heat and corrosion resistant metals. We have solved problems for many firms over the years—we can undoubtedly help you. Send for Catalog.

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Stanwood  
Representative  
Near You!

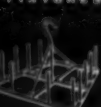
CARBURIZING  
BOXES



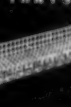
BASKETS



FIXTURES



TRAYS



QUENCH TANKS



RETORTS



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## WHY

### DO YOU ALLOW RAPID WEAR ON YOUR BUFFING FIXTURES

when they can be **FUSECOATED** to last up to a year or more? We specialize in protective coatings for fixtures of all kinds and would like to add your name to our long list of regular customers.

Write

for our general information folder or send sample fixture or drawing of same to be FUSECOATED.

**Fusion Metal Coating Co.**

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## RUST-LICK IN AQUEOUS SYSTEMS

**Grade "B"**

**FERROUS  
METAL PROCESSING**

Eliminates . . .

*Rust  
Fire Hazards  
Toxicity  
Dermatitis  
Degreasing*

Write for free sample and brochure  
Specify Grade "B"

**PRODUCTION SPECIALTIES, INC.**  
755 BOYLSTON STREET  
BOSTON 16, MASS.

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## WHITELIGHT MAGNESIUM

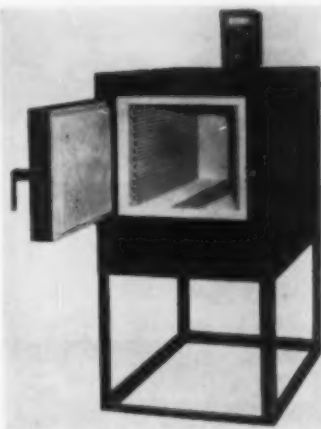
your comprehensive independent  
mill source of magnesium alloy  
Tubes • Rods • Shapes • Bars  
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Riveted structures and assemblies



**WHITE METAL ROLLING  
& STAMPING CORP.**

82 Moultrie St., Brooklyn 22, N. Y.  
Sales Office  
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More than two thousand satisfied users  
WILL TESTIFY YOU

### SAVE 3 WAYS WITH A LUCIFER FURNACE

#### 1—Save on First Cost

CHECK THESE PRICES

Furnace Size	2000°	2300°
6x12"	\$ 500.00	\$ 600.00
9x18"	750.00	850.00
12x12x24"	1000.00	1100.00
18x18x36"	1500.00	1600.00

Complete with 100% automatic  
electronic controls.

#### 2—Save on Man Hours

Less operator attention needed—Lucifer controls  
are EXACT. They reach SPECIFIED heat rapidly  
and retain SPECIFIED temperature without varia-  
tion. No special experience required when you use  
a Lucifer Furnace.

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Finest refractory materials are built into Lucifer  
Furnaces for better, more efficient heat retention.  
Elements are guaranteed, long lived, trouble free.  
WRITE FOR FREE LITERATURE, specifications  
and price list of Lucifer Furnaces in wide range  
of sizes—top loading and side loading types.  
Engineering advice without obligation. Write,  
wire or phone today.

**LUCIFER  
FURNACES, INC.**

DESMOND, PA.  
Phone Columbia 5-0411

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## MANHATTAN

**Abrasive Wheels — Cut-off Wheels  
Finishing Wheels—Diamond Wheels**

Custom-made for your specific  
material removal problems

**Foundry Snagging—Billet  
Surfacing—Centerless Grinding**

**Cutting and Surfacing concrete**  
granite, and marble

**"Moldiscs" for rotary sanders**

**Grinding and Finishing**  
stainless steel welds

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**Cutting-off—Wet or Dry Bars, Tub-  
ing, Structural, etc. Foundry Cutting**

—standard and reinforced wheels  
**Grinding Carbide Tipped Tools**

Write to Abrasive Wheel Department

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MANHATTAN RUBBER DIVISION  
92 TOWNSEND ST. • PASSAIC, N. J.

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**CALL WIRETEX  
for WIRE BASKETS  
and FIXTURES**

Here at WIRETEX we have  
the most Modern equipment and  
facilities for fabricating baskets and  
fixtures for all your plating and heat  
treating requirements—to resist acid,  
rust, abrasion or exposure in every  
weather, metal and alloy.

Test our Service, Quality and Price  
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**Wiretex mfg. co.**

3 Adams St., Middletown 3, Conn.  
Specialists in Processing Carriers Since 1932

LIST NO. 114 ON INFO-COUPON PAGE 169

# JELLIFF

# BASKETS



for ALL Industrial Uses

- Degreasing
- Anodizing
- Pickling
- Plating
- Heat Treating
- Heavy Industrial Types

ANY SIZE AND SHAPE • ANY DUCTILE METAL

Ask for Bulletin 28



## THE C. O. JELLIFF MANUFACTURING CORP.

SOUTHPORT • CONNECTICUT

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### Soluble Gold

### Soluble Rhodium

Technic solutions, like Technic advisory service, set the standards for precious metal electroplating.



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Jackson 1-4200  
Chicago Office: 7001 North Clark Street

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# RUST-LICK

IN  
AQUEOUS SYSTEMS

## Grade "C-W-25"

*Non-flammable*

*Non-toxic*

*Aqueous Oily Film*

*Protects Ferrous Parts*

*for Long Periods*

*Indoor Storage*

*Write for free sample and brochure  
Specify Grade "C-W-25"*

PRODUCTION SPECIALTIES, INC.  
755 BOYLSTON STREET  
BOSTON 16, MASS.

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## WESTERN METAL

## EXPOSITION

March 25 to 29, 1957

Pan-Pacific Auditorium

Los Angeles, Calif.

*Noble Metals  
are put  
to work!*

**Sel-Rex**

AN CONNECTOR  
by AMPHENOL

**Sel-Rex Precious Metals, Inc.**  
Dept. 88, 289 Main Street  
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WANT SEL-RX • AMPHENOL • TITAN • FALCON • PLATING

## Precious Metal Processes FOR INDUSTRIAL APPLICATIONS

Developed specifically for industrial application, Sel-Rex Precious Metals offer many advantages over conventional processes. One gram of Sel-Rex BRIGHT GOLD, for example, does the job of 2 grams of regular 24 K. gold, because the deposits are more dense and twice as hard. Gives mirror bright finish directly from the bath, regardless of thickness requirements — eliminates costly scratch brushing, buffing and burnishing.

Sel-Rex BRIGHT RHODIUM meets the need of today's precise engineering applications with A. S. C. — Automatic Stress Compensation — a special technique which counteracts the high stress characteristics of conventional precious metal electroplates. Non dusting Sel-Rex Silver SOL-U-SALT is added directly to the plating bath, eliminating time consuming filtering or mixing — a cost cutting advantage exclusive with Sel-Rex.

LIST NO. 108 ON INFO-COUPON PAGE 169

**WELDCO****FABRICATED MONEL  
PICKLING EQUIPMENT**

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

**THE YOUNGSTOWN WELDING & ENGINEERING CO.**

3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

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**CIRCO Metal Cleaning Equipment CUTS costs**

SINCE 1923

**EQUIPMENT COMPANY**119 Central Avenue, Clark (Rahway), N. J.  
Offices and warehouses in principal cities**CIRCO VAPOR DEGREASERS**—large or small—automatic or manual operation**CIRCO METAL PARTS WASHERS**—custom engineered to suit your production needs**CIRCO-SONIC DEGREASERS**—newest development—cleaning by ultra-sonic vibration**CIRCO-SOLV** (Trichlorethylene) and **PER-SOLV** (Perchloroethylene)—high purity, low-cost solvents**FREE! Write for 32-page CIRCO Degreasing Manual**

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New book contains papers and talks by 39 experts. Subjects covered are: reduction, processing and fabrication, properties, the brittleness problem, metallography, corrosion, beryllium-rich alloys, cermets and ceramics, health hazards and analytical chemistry of beryllium.

Price—\$8.00

**AMERICAN SOCIETY FOR METALS**7301 Euclid Ave.  
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**HARDNESS TESTING  
SHORE SCLEROSCOPE****Pioneer American  
Standard Since  
1907**

Available in Model C-2 (illustrated), or Model D dial indicating with equivalent Brinell & Rockwell C Hardness Numbers. May be used freehand or mounted on bench clamp.

**OVER 40,000  
IN USE****SHORE INSTRUMENT & MFG. CO., INC.**  
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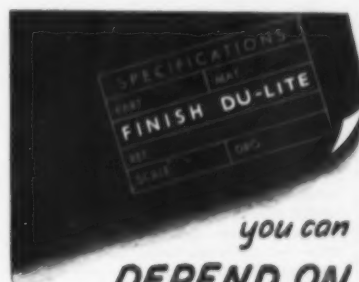
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IN  
BRINELL  
AND  
VICKERS  
TESTS**SAVE  
TIME and  
TROUBLE**Eliminate the Tedious  
Microscopic Measurements  
of the Indentations.Use Gries REFLEX  
Machines with Carl  
Zeiss Automatic Pre-  
jection System**INVESTIGATE**

Write for Bulletin No. A-14

**GRIES INDUSTRIES, INC.**Testing Machines Division  
NEW ROCHELLE 3, N.Y.

LIST NO. 135 ON INFO-COUPON PAGE 169



*you can  
DEPEND ON  
Du-Lite  
to meet your  
specifications*

Du-Lite black oxide finishes for steel, stainless, copper, zinc or malleable iron provide a uniform, durable surface without altering the dimensions or physical characteristics of the metal. That's why they are often specified right on the blueprint.

And since the Du-Lite process is simple, flexible, and imposed at non-critical temperatures, you can depend on the results to meet your specifications—always.

Du-Lite black oxide finishes also meet govt. specs. MIL-F-13924, superseding 57-0-2C Type III Class A for steel and Class B for stainless (Type II Class B and C phosphates), and MIL-P-12011, superseding 51-70-1A para. 22.03 Class C for Copper and Copper Alloys. Whatever your metal cleaning or finishing problem, consult—

**Du-Lite****DU-LITE CHEMICAL CORP.**  
MIDDLETOWN, CONN.

LIST NO. 103 ON INFO-COUPON PAGE 169

## Inspection Demagnetizing or Sorting PROBLEMS?

### SOLVED with

#### MAGNETIC ANALYSIS MULTI-METHOD EQUIPMENT

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 80 installations in steel mills and fabricating plants.

#### MAGNETIC ANALYSIS SPECIAL EQUIPMENT

Electronic Equipment for non-destructive production inspection of both non-magnetic stainless and high temperature steel bars and tubing—seamless or welded—as well as non-ferrous bars and tubing. Mechanical faults, variations in composition and physical properties are detected simultaneously. Average inspection speed 200 ft. per minute.

Over 30 installations in mills and fabricating plants.

#### MAGNETIC ANALYSIS COMPARATORS AND METAL TESTERS

Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

#### MAGNETIC ANALYSIS DEMAGNETIZERS

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

#### MAGNETIC ANALYSIS MAGNETISM DETECTORS

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

TRADE MARK



For Details Write:

**MAGNETIC ANALYSIS CORP.**  
42-44 Twelfth St., Long Island City 1, N. Y.

"THE TEST TELLS"

LIST NO. 51 ON INFO-COUPON PAGE 167

## TENSILKUT

Patent Pending

Accurate tensile specimens machined  
from sheet and plate materials  
.0005 to .500 inch  
in less than three minutes



#### MACHINES METALS AND NON-METALLICS

Copper—Steel—Aluminum  
Titanium — 17-7 Stainless — Brass  
Magnesium—Lead—Molybdenum  
Fiber Glass — Rubber — Acrylics

#### TYPICAL USERS OF TENSILKUT

Bethlehem Steel — Republic Aircraft  
American Brass—Chrysler  
General Electric — Douglas Aircraft  
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Acme Steel — Crucible — U.S. Steel

#### FOUR MODELS NOW AVAILABLE

Capacities to .125", .250", & .500"

## SIEBURG INDUSTRIES

INCORPORATED

HORSE PLAIN ROAD • NEW BRITAIN, CONN.

LIST NO. 131 ON INFO-COUPON PAGE 169



## Impressor

for quick, on-the-spot hardness testing  
of non-ferrous metals and plastics



Simple to operate . . . gives an instant, dependable measure of hardness. Operates on principle of forcing a spring-loaded indenter into the surface with the amount of penetration registering on a dial indicator. Can be used in any position . . . tamperproof . . . compact . . . rugged, yet weighs only 12 oz. Thousands used by industry. Write today for complete details.

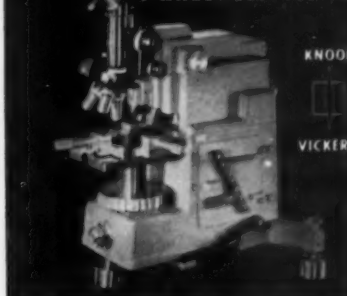
**Barber-Colman Company**

Dept. J, 1218 Rock St., Rockford, Illinois

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## KENTRON

MICRO  
HARDNESS TESTER



KNOOP

VICKERS

Applies 1 to 10,000 gram loads

Write for Bulletin

**Kent Cliff Laboratories Div.**

The Torsion Balance Company

CLIFTON

NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 169



NOW IT'S HERE!

THE 500 LB. CAPACITY

**MOREHOUSE**

PROVING RING!

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National Bureau of Standards Certified  
. . . Available in both compression  
and tension types.

This newest Morehouse Proving Ring brings dependable accuracy to the calibration of mechanical-force-indicating devices in the lower capacity range (from 50 to 500 lbs.).

Like all Morehouse Proving Rings, this 500-lb. model is backed by more than 30 years of precision instrument manufacture in this highly specialized field. Assures accuracy within 1/10th of 1%.

Also investigate Morehouse Weighing and Calibrating Systems, Ring Dynamometers, Calibrating Machines, and the Morehouse Consulting Service.

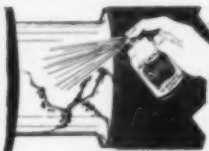
Write for FREE illustrated complete-line catalog.

**MOREHOUSE MACHINE COMPANY**

"World Leader in Precision Calibration"

233 West Market Street • York, Pennsylvania

## DYELINE INSPECTION PROCESS



Dyeline—a new two-stage inspection process for all non-porous materials. No skilled operator or expensive equipment necessary! Just spray Dyeline, follow with Dyeline Detector, and the exact location, type and extent of defects appear sharply and clearly on an opaque background! No solvent required—water removes Dyeline immediately.

WRITE FOR DETAILS

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LABORATORIES**

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### ALSO:

**ZIP SPEED LACQUER**—Identifies all materials with a quick color-coding process.

**ZIP RUST STOPPER #1**—Protects metal parts for storage.

**ZIP RUST STOPPER #2**—Protects parts left in machinery for further processing; removes fingerprints.

**ZIP PATTERN LAYOUT FLUID**—Shows up scribed patterns strongly.

**ZIP STENCIL INK**—Quick drying—excellent on cartons and metals.

**ZIP BELT LUBE**—Prolongs belt life, promotes safety and speed.

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## ULTRASONIC

Thickness Testing from One Side

*Rapid, Accurate, Non-Destructive*

### VIDIGAGE®

14" or 21" Cathode-Ray Screen with direct-reading scales between 0.005" and 2.5"; accuracy 0.1% to 1.0%.

### AUDIGAGE®

Portable Thickness Testers for ranges from 0.020" to 4" or 0.060" to 12" of steel; accuracy up to 1.0%.

Detect Laminar Flaws and Lack of Bond

**BRANSON  
INSTRUMENTS, INC.**

6 Brown House Rd., Stamford, Connecticut

*Specializing  
in Ultrasonics  
Since 1946*

LIST NO. 81 ON INFO-COUPON PAGE 169

the TRUE TEST is

*Taber*



**TABER  
Abrasion  
TESTER**

Tests wear resistance of metal, plastic, paint, rubber, leather, paper, foil, etc. With average technical experience, anyone can make a scientific, comparative abrasion resistance test with this instrument.

**TABER  
Stiffness  
TESTER**



Determines the initial, basic stiffness or resilience of sheet and wire specimens. Eight test ranges provide wide application. Test length, angle of deflection, rate of loading all standardized for accurate results between laboratories. Scale calibrated in gram centimeters.

Write for Illustrated Literature.

**TABER INSTRUMENT CORPORATION  
SECTION 19**

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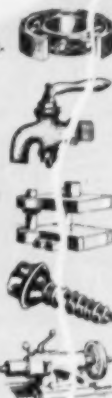
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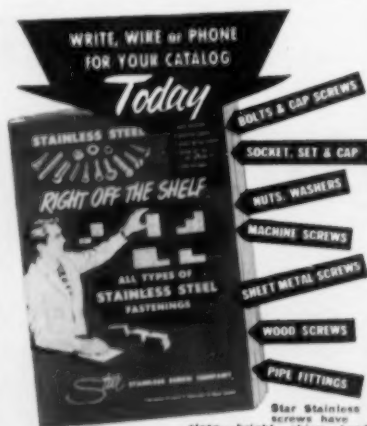


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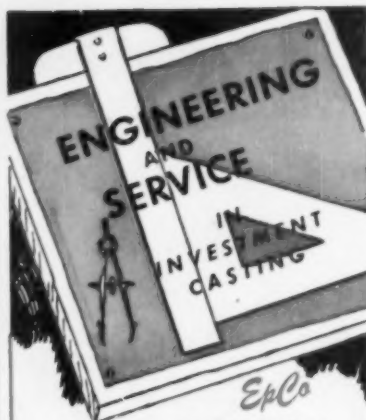
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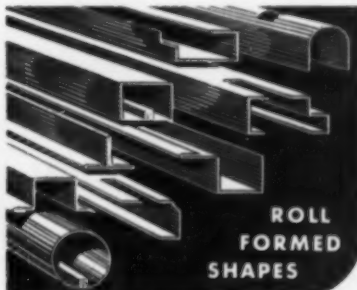
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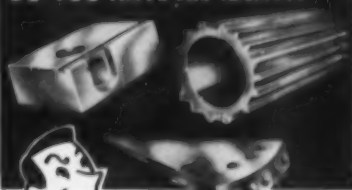
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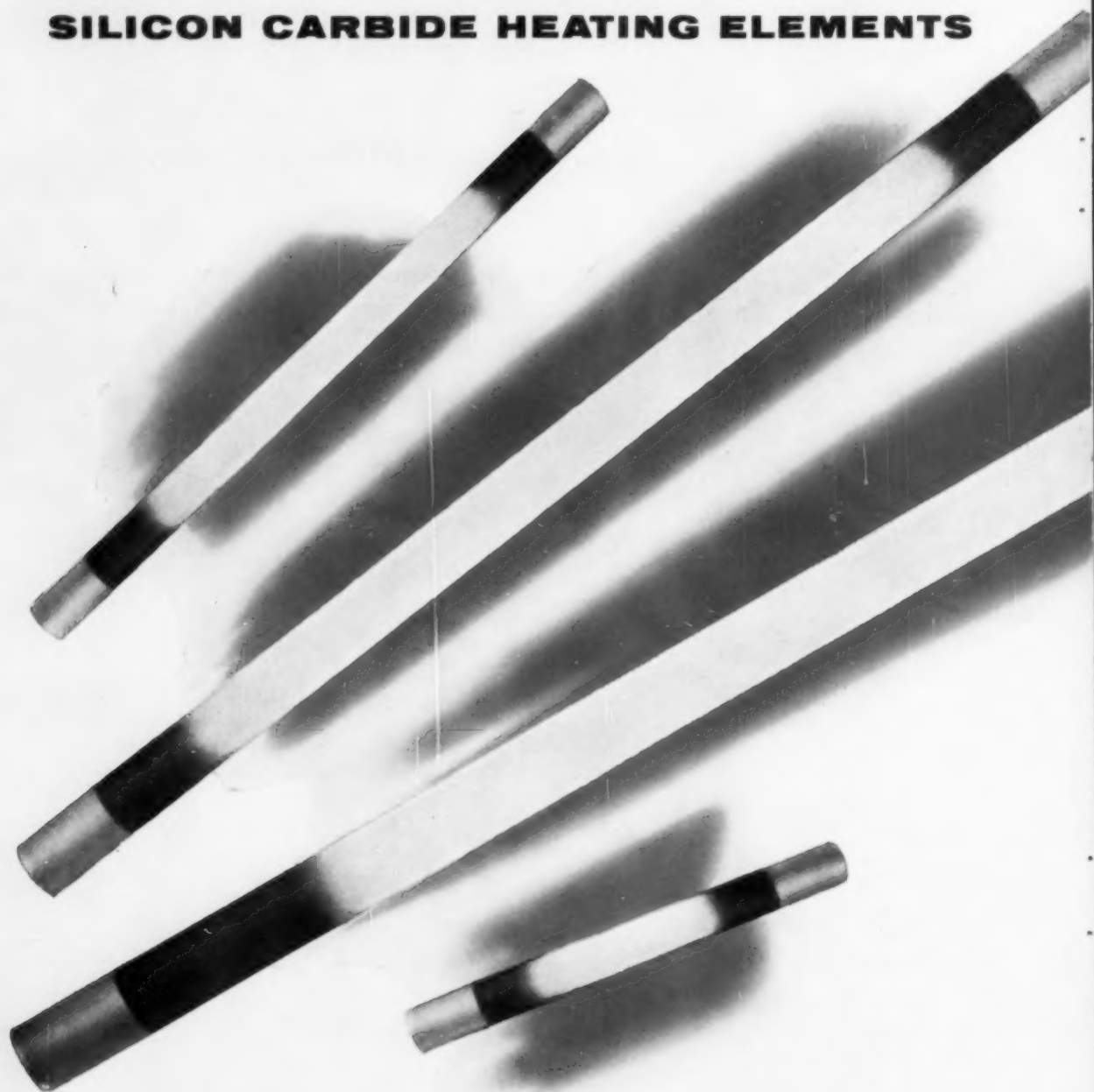
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## Desulphurization of Hot Metal

Digest of "Soda Ash Desulphurization in England", by C. A. Shanahan, *Iron & Steel*, Vol. 29, January 1956, p. 9 to 14.

THE INCREASE in the ratio of hot metal to cold scrap in the steel-making operations of British open-hearth furnaces has caused increasing refining delays because of the

high-sulphur content of the British hot metal. Basic bessemer plants in England control this problem by desulphurizing the high-sulphur hot metal with soda ash before blowing the pig iron in the basic converters. This article reports a study of soda ash desulphurization practices at nine openhearth steel plants.

The sulphur content of the hot metal at the nine different shops ranges from 0.05% to as high as 0.31%. Although American steel

plants have usually been able to maintain a maximum of 0.05% sulphur in hot metal for openhearth, the recent trend to the use of high-grade imported ores and taconite concentrates with the resultant low slag volume in the blast furnace has made the control of sulphur in the hot metal more difficult. Increasing sulphur content in blast furnace coke in some areas is also contributing to this difficulty.

Of the nine works visited, four had abandoned the use of soda ash because of the deleterious effects of the treated metal on the mixer or openhearth refractories and to a lesser extent, because of discomfort to operators caused by the fumes evolved. This latter difficulty arose in older plants where the layout did not lend itself to the installation of efficient ventilation. The five other works were satisfied with the process and either used it for a proportion of the blast furnace output according to the iron analysis or for the whole iron output. At four of the plants, the desulphurized iron was processed either in a mixer, open-hearth furnace or converter (acid or basic) without encountering any appreciable increase in fettling or wear of the furnace refractories.

The use of lime or limestone appears to thin the soda slag up to a certain concentration but above that again thickens it; the thickening action is desirable in so far as it facilitates the removal of the soda slag. Theoretically, limestone might be more beneficial than lime in that the evolution of carbon monoxide and carbon dioxide would assist in the agitation of the slag and metal but, on the other hand, extra cooling of the metal would result. More precise information on the effects of lime and limestone additions would be of value.

In general, the methods of carrying out the soda ash process varied considerably because of the difference in plant layout. In most instances the plants had been designed and built before the advent of the soda ash process. At one plant covered ladles are used to keep the iron hot and help to control the fumes. At the same plant the technique of skimming into another ladle and thus collecting any iron brought over with the slag permits high skimming efficiency without undue loss of iron. Another plant uses a particularly

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## Desulphurization . . .

vigorous decanting which must contribute to the desulphurizing efficiency. The Bilston method of placing a dam in the iron runners seemed particularly efficient during the brief period in which its operation was observed. It therefore is reasonable to suppose that in any new works where the soda ash desulphurization is to be started the use of covered ladles, vigorous decanting, a carefully designed skimming system and a judicious addition of lime or limestone with the soda ash would lead to a very efficient process. While "teapot" or "coffeepot" ladles have been mentioned in connection with slag skimming they did not seem popular but finality in their design has not yet been reached.

E. C. WRIGHT

## Stress Analysis of Metal Forming Operations

Digest of "Research Into Some Metal-Forming and Shaping Operations", by W. Johnson, *Journal of the Institute of Metals*, Vol. 84, March 1956, p. 165-179.

WHEN a cup is formed from a flat circular blank, the metal near the mean cup diameter is subjected to biaxial tension and plastic bending under tension, and the metal in the outer part of the blank is subjected to true radial drawing combined with plastic bending. Between these two lies an area which escapes bending and only transmits the drawing force.

A portion of an elementary ring in the rim of a partially drawn cup is subjected to compressive thickness and hoop stresses and a radial tensile drawing stress whose magnitude is dependent on friction. When the material reaches the shoulder of the die, it is plastically bent and subsequently unbent over the die profile while under substantial tensile stress in the "radial" direction. This leads to metal thinning and modifies the thickening which occurred during radial drawing. Straining ceases at or just beyond the throat of the die. Based on certain assumptions, the thinning

strains and drawing stress can be computed.

The expressions derived theoretically were in good agreement with experimental results. Some general conclusions were:

1. Punch load increases with increase in blank diameter.
2. Thicker blanks require greater drawing loads but ease blank holding conditions.
3. Die profile radii greater than ten times the metal thickness have little effect on frictional forces.
4. The punch radius has little effect on punch load but does influence thickness of cup walls.

Whether or not a metal is capable of transmitting the drawing load depends on conditions over the profile of the punch, the kind of lubrication and the ductility of the metal. As a general rule, fracture occurs on the profile curve where critical thinning develops.

The flange portion of the blank is subjected to radial drawing stress and an induced compressive hoop stress. When the magnitude of these exceeds a critical value, wrinkling occurs. For an unsupported flange, instability can be predicted from flange dimensions using a theoretical formula. If blanks are used below the critical size, the depth of cup which can be obtained is limited. Wrinkling is restrained in practice by a blankholder which results in a greater number of low amplitude waves formed by reverse buckling. Theoretical equations have been developed which give the number of waves for the two types of blankholders.

Tests were made to establish the validity of residual-stress measuring techniques. Davidenkov's analysis is considered the more exact of the analyses based on bending deflection but requires more labor than the simpler, less accurate Sach and Espey analysis. The Sachs boring method is exact but requires careful technique. The acid pickling process is satisfactory in all respects. In a hollow drawn tube the stresses are not uniform and do not necessarily increase with the degree of reduction.

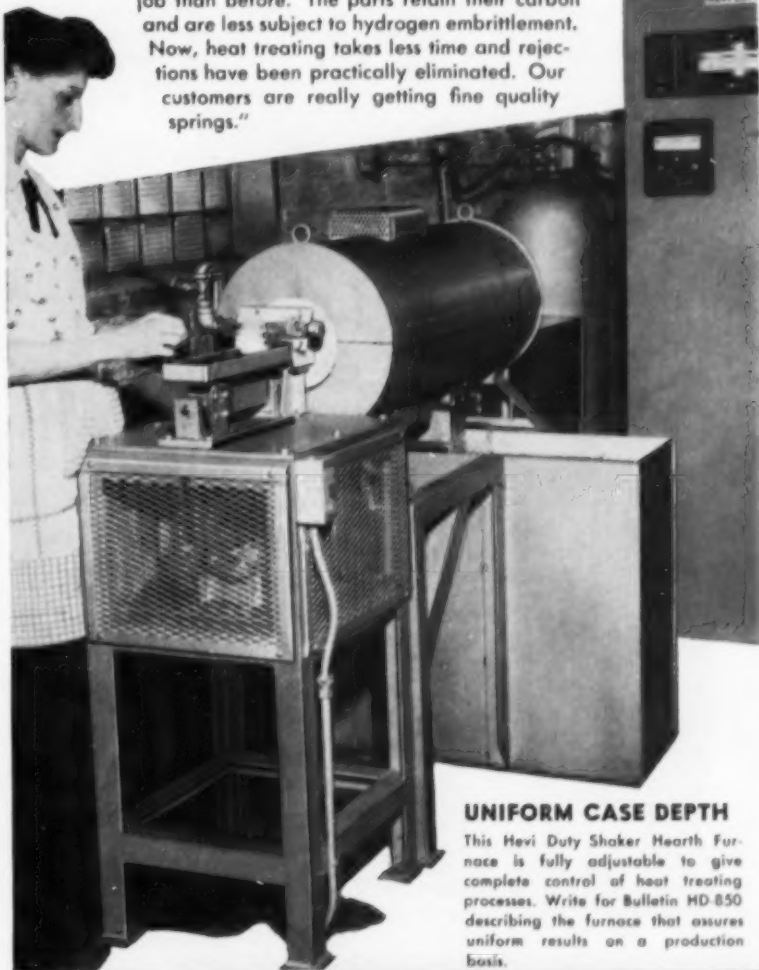
In slow-speed cold extrusion, the work done by the punch is the sum of that which causes metal to flow and that which overcomes friction between metal and wall. The energy requirements may be predicted

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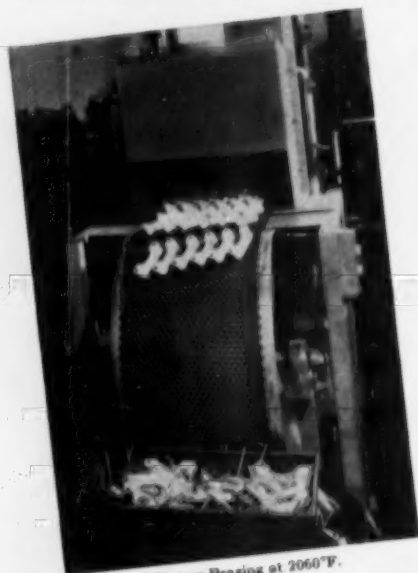
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## Metal Forming . . .

but when impact extrusion is considered the forces are no longer simply related. The major modifying factors are the effect of rate of strain and the effect of inertia and resilience of tools.

Coining tests were made on samples of unlubricated lead and aluminum. At high pressures, the frictional stresses are often equal to the shear strength of the metal. A greater load is required to achieve a given degree of coining under static or slow-speed coining.

R. F. HARTMANN

## Crater Wear of Cutting Tools

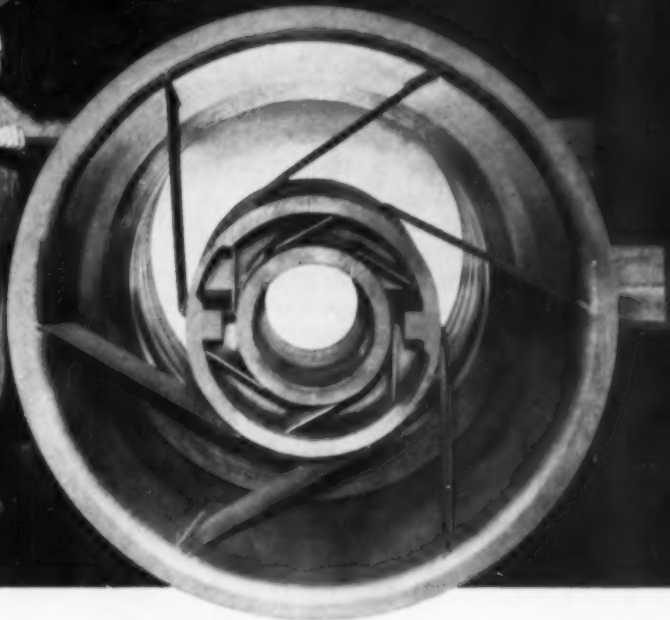
Digest of "Crater Wear of Cutting Tools", by K. J. Trigger and B. T. Chao, American Society of Tool Engineers Preprint No. 24 T 38, 1956.

USEFUL life of a cutting tool is limited by wear occurring either on the top face or on the clearance face (flank). The former is known as crater wear and is normally observed a slight distance away from the cutting edge. Craters have been observed on tools cutting both materials which produce a continuous chip and such materials as spherulitic iron which form discontinuous chips.

To obtain a clearer picture of the mechanism of crater wear, tests were run on A.I.S.I. 4142 steel annealed to Brinell 212, using titanium carbide, tungsten carbide and 18-4-1 high speed steel tools. Cutting tips were triangular inserts, about 1/8 in. on a side and 1/2 in. thick, mechanically attached to a steel shank to permit removal for sectioning. All runs were made with air as the cutting fluid on a 16 x 54-in. heavy-duty lathe equipped with stepless speed control.

Tool forces were measured with a sensitive dynamometer, and tool-chip interface temperatures by the tool-work thermocouple technique. Instantaneous surface speeds were checked by an indicator and clocked by a counter which recorded rpm. during the elapsed time of a test. Continuous records of tool forces or tool-chip interface temperatures

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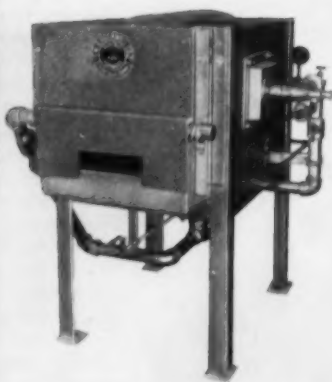
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## Cutting Tools . . .

were obtained during a cut to detect  
any changes or discontinuities due  
to tool wear or chip short-circuiting.

For crater volume measurement,  
the tool was sectioned in a plane at  
half depth in the direction of chip  
flow. After etching, the crater section  
was photographed at approximately  
100X and the micrograph projected  
onto a sheet of graph paper so that  
the contour of the crater could be  
traced and measured. The presence  
of adhering work material did not  
interfere with the measurement since  
the boundary was clearly discernible  
after etching.

One theory of crater wear is pos-  
tulated on diffusion and alloying at  
the tool-chip interface. The action of  
the heated chip sliding over the top  
surface of the tool makes it appear  
logical to regard the resultant wear  
as frictional. It can be attributed to  
two mechanisms:

1. Adhesion and transfer wear in  
which rupture occurs in a thin layer  
of tool material adjacent to the tool-  
chip interface as a result of weaken-  
ing due to diffusion and alloy forma-  
tion. For a given tool-work combina-  
tion, temperature and its distribution  
at the sliding contact are governing  
factors.

2. Abrasion or plowing wear  
which depends primarily upon the  
relative hardness of the tool and chip  
under cutting conditions, the amount  
and distribution of hard constituents  
(including impurities) in the work  
material, degree of strain hardening  
and other variables.

Importance of tool-chip interface  
temperature on crater wear was  
demonstrated conclusively in the test  
work here reported. Insofar as the  
rate of metal removal is concerned,  
the benefits accruing from an in-  
crease in feed with a compensating  
decrease in speed to maintain the  
same temperature are striking. For  
example, a feed of 0.01265 in. per  
revolution at 81 ft. per min. and  
feed of 0.00736 in. per revolution at  
115 ft. per min. both exhibit the  
same average temperature (950° F.)  
at the interface. However, the rate  
of metal removal is some 21% greater  
with the higher feed rate. The infer-  
ence is that in many instances un-  
warranted emphasis is placed on  
higher speeds rather than higher  
feeds. (Continued on p. 180)

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## Cutting Tools . . .

An observed constancy of crater wear in conjunction with the temperature dependence of such wear suggested that the temperature during a prolonged cut was substantially constant. This was borne out by a continuous record of interface temperatures over a 15-min. cut. Thirteen successive readings all fell in the range of 955 to 965° F.

Summarizing the test results, three

generalizations may be cited:

1. For a given cutting condition, the crater wear rate of a cutting tool is substantially constant.

2. For a given tool-work pair, the tool-chip interface temperature is the principal factor affecting the rate of crater wear.

3. Both high speed steel and carbides exhibit a temperature sensitive range in and above which the crater wear rate increases rapidly with small rise in temperature.

ARTHUR H. ALLEN

## Titanium and Lead in Nodular Cast Iron

Digest of "A Note on the Subversive Influence of Titanium and Lead in Nodular Cast Iron", by J. V. Dawson, *Journal of Research and Development*, British Cast-Iron Research Association, Vol. 6, April 1956, p. 180-183.

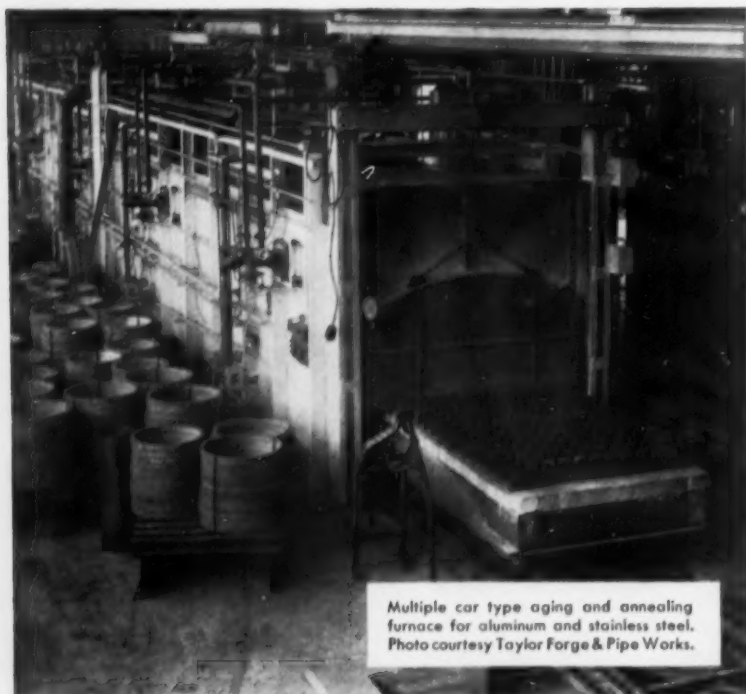
DELETERIOUS effects of a small amount of titanium and lead on the development of nodular structures in cast iron treated by the magnesium process are well known. The potency of titanium in this regard is enhanced by the presence of a trace of lead. The combination of as little as 0.1% Ti and 0.003% Pb has been found to be completely damaging to nodule formation although without lead, 0.1% Ti can be tolerated.

To substantiate these conclusions, three experimental heats of nodular iron were produced with varying additions of titanium, both with and without lead. Swedish charcoal pig iron was used as a base, with ferrosilicon (80% Si) and ferromanganese (70% Mn) added to give the required composition of approximately 3.5% total carbon, 2.34% Si, 0.50% Mn, 0.010% S and 0.020% P.

Magnesium was added to the ladle iron at 2460° F. in the form of Ni-Mg alloy containing 17% Mg. One ounce of alloy was used for 10 lb. of iron to give a residual magnesium content of 0.05% and nickel about 0.45%. The melt was inoculated with ferrosilicon and allowed to stand 45 sec. before pouring the castings. Titanium was introduced as a ferrosilicon-titanium alloy with 20% Ti, 15% Si and 1% Al.

Two standard keel blocks were cast from each of six taps in the first melt. The titanium contents of the successive taps were less than 0.02, 0.07, 0.08, 0.15, 0.13 and 0.32%, respectively. The titanium content of the fifth tap was lower than anticipated due to a poor yield from the addition. Tensile tests were made on bars cut from the keel blocks and specimens for micro-examination taken from the tensile bars after physical testing.

Results of the tensile tests and micrographic examination indicated that titanium does not influence the formation of nodular graphite in the absence of lead until more than 0.08% is present. Only a slight effect



Multiple car type aging and annealing furnace for aluminum and stainless steel. Photo courtesy Taylor Forge & Pipe Works.

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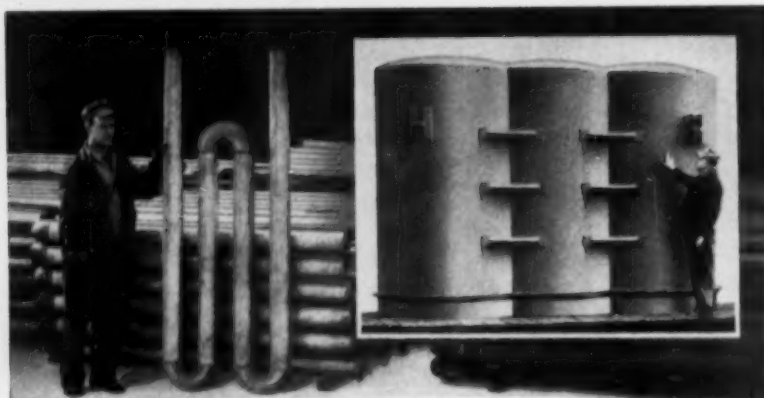
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## Nodular Iron . . .

is noted from 0.13% Ti and even at 0.15%, the short compacted flakes have little effect on tensile properties of the iron. However, the coarse pointed flakes induced by 0.32% Ti have a completely damaging influence and cause the tensile strength to drop from 60,200 to 36,000 psi. and elongation from 11 to 1%.

A second melt was given a basic titanium content of 0.1% and divided into four taps with no lead addition, 0.003%, 0.006% and 0.012% Pb, respectively. In this instance, the inclusion of 0.1% Ti was harmless in the absence of lead, but the smallest addition of the latter element resulted in a preponderance of flake graphite and dissipated the ductile properties of the iron. With increasing lead content, ultimate tensile strength dropped successively from 60,600 to 43,800, 25,200 and 17,600 psi. and elongation from 18 to 3, 1 and 1%.

The third melt was processed the same as the second. No titanium was added although lead was introduced as in the second melt. In this experiment, the smallest lead addition considerably reduced ductile properties but not nearly as much as when the titanium was included. With no lead, the structure was all nodular; with 0.005% Pb, about 10% flake graphite and the rest nodular; with 0.008% Pb, about 50-50; and with 0.009% Pb, all flake graphite.

The obvious deduction from these tests is that much more titanium can be tolerated in the iron in the absence of lead than hitherto thought possible.

There is some disagreement with earlier findings of H. Morrogh who determined that good nodular iron structures could be obtained only when titanium was less than 0.04%. As a check on this conclusion, advanced in 1952, some of the samples of iron made by Morrogh in his titanium experiments were carefully analyzed for lead content. As much as 0.002% was found to be present in samples where less than 0.1% Ti was reported subversive. Inference is that in these specimens lead must have been present as an impurity in the Swedish pig iron used, no doubt accounting for the reasoning that titanium in such small amounts was harmful.

ARTHUR H. ALLEN

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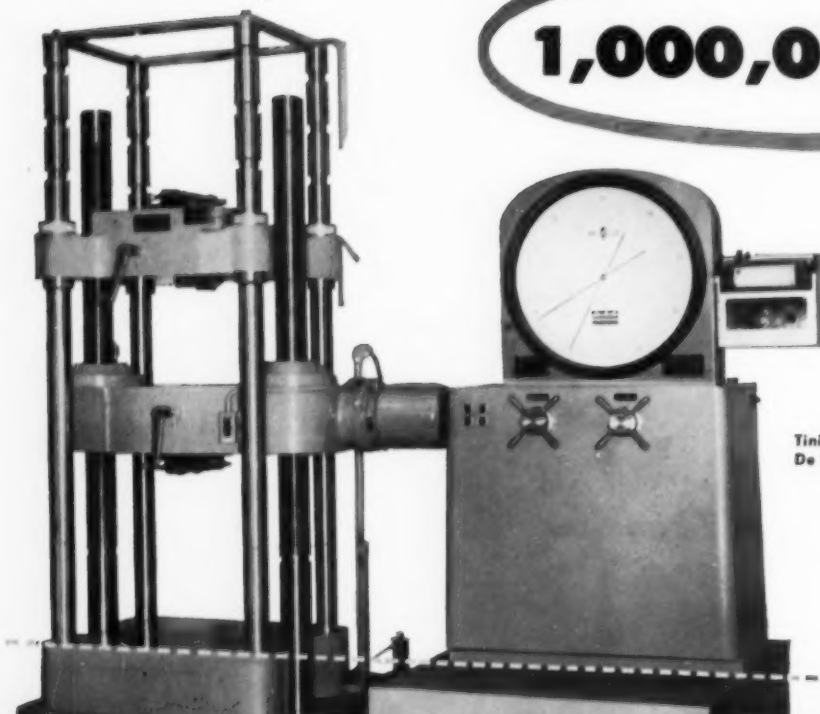


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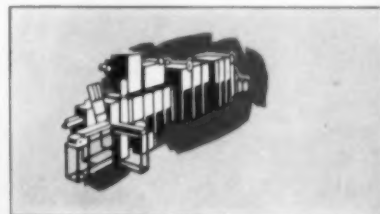


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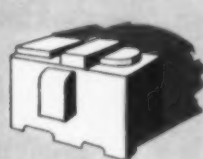
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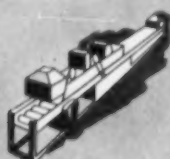
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## Fracture in Metals

Digest of "Fracture in Metals", by N. F. Mott, *Journal of the Iron and Steel Institute*, Vol. 183, July 1956, p. 233-243.

THE STRESS required to move a dislocation in a crystal has not been determined, but in hexagonal or face-centered cubic structures, it is probably very small, while in body-centered metals such as iron, it may be quite large at low temper-

atures. Interstitial impurities, such as carbon or nitrogen in iron, segregate on the dislocation lines and thus produce a yield point by hindering the movement of the dislocation.

Since slip in metals is always localized on active slip planes a few microns apart, and slip on each plane is started by movement of a dislocation, there must be sources of dislocations in the metal which can produce the dislocations when stress is applied. An explanatory theory

that has been proposed is that a certain arrangement of dislocations, when stressed, is capable of producing new ones.

When a slip plane terminates at a grain boundary, dislocations must become concentrated near the boundary and the stress is also concentrated as by a notch. If the localized stress becomes sufficiently high, either the material at the end of the slip line will separate to form a crack or further slip will occur at dislocations generated from nearby sources.

Brittle or cleavage fracture in metals is probably initiated by slip in this way and not by surface cracks such as occur in glass when it is cooled. Grain boundaries which stop slip lines from spreading are a requirement for brittle fracture. For both brittle and ductile fractures the net applied stress must exceed a constant times the elastic shear modulus multiplied by the square root of the interatomic distance divided by the grain diameter. If the crack is damped out by plastic flow around its apex, the fracture is ductile and if not, brittle. In low-carbon steel, the fracture stress has been shown to increase linearly with the grain diameter, whether the fracture was brittle at  $-320^{\circ}\text{F}$ . or ductile at room temperature or above. The constant has been found by experiment to be 2.0 for iron, 1.2 for zinc, 0.69 for magnesium and 3.9 for molybdenum.

Cracks at the ends of slip planes in a grain cannot spread into a brittle fracture unless the nearby sources of dislocations in the metal are locked by impurities. Where locking is weak, ductile fracture occurs; with a large number of microcracks merging. The stress required to overcome locking of the sources is very sensitive to temperature and time must also be available for dislocations to traverse the slip line at about the velocity of sound. The actual details of these relations remain to be determined by experiment. The lower yield point in steel has been explained as the stress causing sources near the ends of slip lines in the grains to generate new dislocations.

The process of fatigue in metals involves the initiation of a crack in a grain and its gradual propagation through the material. In ductile metals, about 90% of the fatigue life

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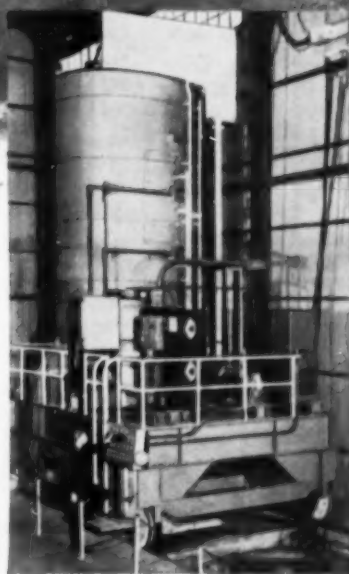


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## Fracture . . .

occurs after the crack is initiated. This is supported by the observation that frequent annealing does not increase the fatigue life, and that removal of the surface after a test is partly finished restores the fatigue life. The fatigue limit is probably the stress below which cracks are not initiated.

Work hardening in single crystals of cubic metals occurs in three stages; in the first stage it is limited to a single system of slip planes and hardening is slow. When two or more slip systems are active the second stage is reached, in which the dislocations are shorter because they are stopped by others in different directions and the rate of hardening is rapid. In the third stage, these barriers are broken down and certain dislocations spread farther across the crystals with slower rate of hardening. It is assumed that these three stages occur under cyclic straining, as well as in simple cold

work, but fatigue is thought to occur only in the third stage. Why a slip line develops into a fatigue crack is not known.

In considering whether dislocations can move backward in slip lines during cyclic stressing, some damping tests on copper in a fatigue test are described that showed the damping to remain constant after hardening was completed. This would indicate that dislocations were moving backward and forward reversibly. A calculation from some other tests on brass leads to the conclusion that an initial fatigue crack must have been produced by the motion backward and forward for only one or two dislocations about 100,000 times. How the slip lines form regions of weakness under cyclic stressing is not known.

In an appendix some calculations are given which indicate that the stress necessary to initiate a crack at the end of a slip line must be about equal to the elastic shear modulus at one atomic distance from the apex. G. F. COMSTOCK

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Price listed is F.O.B. Pittsburgh, Pa.

Other models available—for thermo-recording or recording only—sensitivities 1 mg. or 0.1 mg.

Ask for Bulletin No. 329

**BURRELL CORPORATION**  
Scientific Apparatus and Laboratory Supplies  
2223 Fifth Avenue, Pittsburgh 19, Pennsylvania

throughout industry—today's job records prove  
modern

# High Speed Steels

—correctly applied—

**show lowest costs**

per cu. in. of metal removed

Today's High Speed Steels keep pace steadily with the ever-higher production requirements of American industry. Improvement in quality and advances in heat-treating techniques combine to produce High Speed Steels cutting at speeds 15 to 100% faster than ever before—lasting longer between grinds than ever before!

*Tougher* than carbides, modern High Speed Steels are *stronger* than carbides, less subject to breakage or edge chipping, and *cost less* than carbides.

We invite you to join the majority of up-to-date users of cutting tools who specify modern High Speed Steels for 90% of their jobs and profit accordingly. Write us for a complete, objective survey of your cutting problems by trained sales engineers.

## Vanadium-Alloys Steel Company

Pioneers in the development of M-2 High Speed Steel and High Carbon, High Vanadium High Speed Steels

Latrobe, Pennsylvania

**SUBSIDIARIES:** Colonial Steel Co. • Anchor Drawn Steel Co. • Pittsburgh Tool Steel Wire Co. • Vanadium-Alloys Steel Canada Limited • Vanadium-Alloys Steel Societa Italiana Per Azioni

### Performance Record

Steel —Vasco Supreme      Tool or Die —Tool Bit  
Work —Boring locomotive piston rings  
Remarks —30 pcs. per grind.  
Carbide tools: broke on first piece.

### Performance Records

### Performance Record

### Performance Record

Tool or Die —Rough Facing Tool

Steel —Vasco Supreme  
Work —Rough & finish facing cast connecting rods.  
Remarks —28 pcs. per grind, 150 pcs. per tool. Carbide, 8 pcs. before breaking.

### Performance Record

### Performance Record

### Performance Record

Steel —Neatro      Tool or Die —Core Die  
Work —Molding iron powders  
Remarks —Replaced carbide on basis of cost and performance.

### Performance Record

Steel —Vasco Supreme      Tool or Die —Scalping Die  
Work —Removing surface of brass, bronze and copper tubing  
Remarks —199,000 ft of tubing and still in good condition. Carbide: broke at 141,000 ft.

### Performance Record

Steel —Red Cut Superior      Tool or Die —Form Cutter  
Work —Form cutting bearing races  
Remarks —1st day of test: Vasco Supreme 157 pcs.; Red Cut Superior 100 pcs.; carbide 35 pcs. 2nd day: Vasco Supreme 193 pcs.; Red Cut Superior 126 pcs.; carbide 35 pcs.

### Performance Record

Steel —Vasco Supreme      Tool or Die —Lamination Die  
Work —Blanking .025" sheet  
Remarks —230,000 pcs. per grind: 10,000,000 pcs. per die. Carbide: die broke at 33000 pcs.; another at 550,000 pcs.

### Performance Record

Steel —Vasco Supreme      Tool or Die —Tool Bit  
Work —Turning cold rolled C-115  
Remarks —Produced twice as many pieces per tool as carbide tools, at rate of 3600 pcs. per day.

## Whatever your furnace needs for control—

There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

**Choose ElectroniK Strip Chart Controllers** for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

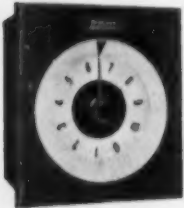


**Choose ElectroniK Circular Chart Controllers** for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.



*Note:* the basic components of all *ElectroniK* models are interchangeable . . . to simplify and speed up service.

**Choose ElectroniK Circular Scale Controllers** where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



*Note:* all *ElectroniK* models are available in both Standard and Precision Series.

**Choose Pyr-O-Vane Controllers** where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument . . . also available with pulse-type time proportioning action, in both vertical and horizontal models.

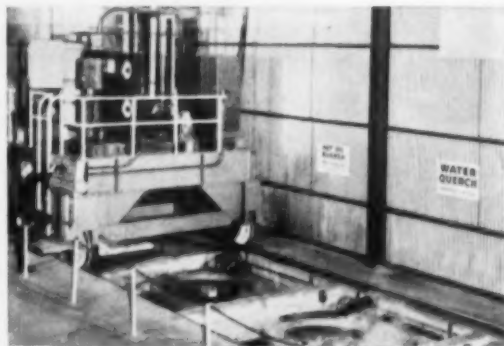


**Choose the Protect-O-Vane Safety Cut-Off** for simple, dependable excess temperature protection . . . can be used with any temperature control to prevent furnace shut downs and loss of production.



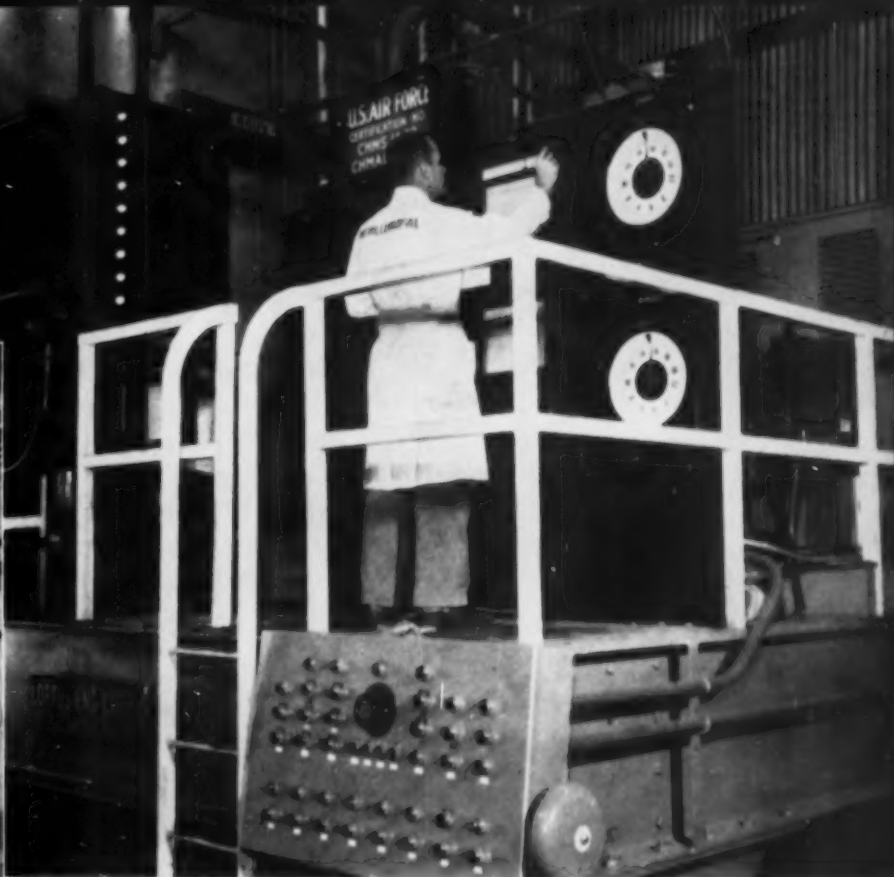
And . . . for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

# Giant vertical drop-bottom furnace kept accurate to 5°...



One operator easily puts the furnace through its paces. The furnace, designed by Loftus Engineering Corporation, has 752 cubic feet of working space.

Parts to be hardened are suspended from an Inconel fixture in the loading end of the pit, hoisted into the furnace through the bottom, then heated. The operator moves the furnace along the tracks over the desired quench—oil, water, or hot salt—and lowers the load into the quench at speeds up to 450 ft. per minute. This process minimizes distortion.



## with *ElectroniK* controllers

**T**HIS furnace at Metallurgical, Inc., Minneapolis, is the largest of its kind in the world. It hardens, anneals, stress-relieves, and normalizes extra-long steel and aluminum aircraft parts in production runs. Temperatures must be held within extremely narrow limits.

For this especially critical temperature control application, Metallurgical chose Honeywell instruments. Two *ElectroniK* circular scale recorder controllers and two *ElectroniK* strip chart recorder-controllers regulate furnace temperatures, which range to 2200°F., with  $\pm 5^\circ$  accuracy. The pre-

cision and sensitivity of these instruments contribute greatly toward consistently high product quality.

*ElectroniK* controllers help any furnace deliver its best. For facts on how they can be profitably applied to your own furnaces, call your nearby Honeywell sales engineer. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO.,  
Industrial Division, Wayne and Windrim Avenues,  
Philadelphia 44, Pa.—in Canada, Toronto 17,  
Ontario.

● REFERENCE DATA: Write for Catalog 1531—"ElectroniK Controllers", "Furnace and Oven Controls" Condensed Catalog and Price List B43-1.



MINNEAPOLIS  
**Honeywell**  
BROWN INSTRUMENTS

*First in Controls*

## Sintering Furnace Maintenance

Digest of "Some Aspects of Sintering Furnace Maintenance", by George Otto, presented at the annual meeting of the Metal Powder Assoc., April 1956.

WHEN a low dew point atmosphere was first used in the sintering of bronze bearings, furnace element failures occurred once every four to six weeks. They were usually in the front element zone of the furnace and were accompanied by arcing and flashing in the furnace.

After a new element was installed

or after a furnace burn-off with air, the current was about 350 amp. The current would rise steadily for several days to about 500 amp. at which point arcing would occur. If arcing persisted, the element would fail. When the furnace was burned off with air, the current dropped to 360 amp.

Examination of the furnace after element failures revealed that they resulted from arcing between the element and the porcelain hangers which support and separate the elements. A deposit which proved to be carbon was observed between the hanger and the element. A carbonaceous deposit was also found on the brickwork in this region but

the rest of the brickwork was relatively clean. It was evident that the carbon deposit made the hanger conductive enough to allow arcing between element and hanger.

Since element failure could be predicted from the record of current, a recording ammeter was made a permanent part of the furnace instrumentation. The current is checked hourly and the furnace is burned off with air to prevent element failure whenever the current characteristics dictate.

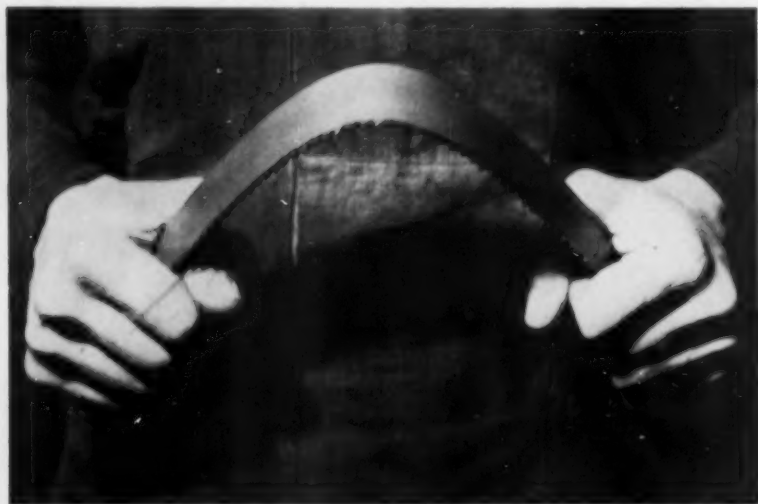
The explanation for the carbon deposit centers around the furnace burn-off procedure. The burn-off removes combustible foreign material deposited during sintering. The bearings being sintered contain 1% each of zinc stearate and graphite. All of the zinc stearate and part of the graphite are lost during preheating and sintering. All zinc stearate should be volatilized during the preheat, but actually some is volatilized in the front sintering zone. Loss of graphite is probably due to reduction of oxides in the compact and mechanical carryout by the gases expelled from the compact.

Prior to the time when manufacture of the bearings was started, the furnace was burned off with air at 1500° F. for 24 hr. once a week. Because this gave a very wet furnace and dry-out time was excessive, an 8-hr. burn-off was used once a week. Apparently this was not enough to remove the carbon completely from the troublesome region of the furnace. Consequently, the weekly 8-hr. burn-off has been augmented by a 4-hr. burn-off in the middle of the week or whenever the current characteristics indicate that it is necessary. The midweek burn-off makes the furnace wet but non-critical work is scheduled while the dew point is being lowered.

Other changes made in the furnace to improve element life include:

1. Lowering the voltage slightly.
2. Feeding gas directly into the troublesome region to increase turbulence.
3. Lowering zinc stearate content from 1 to %.
4. Narrowing the furnace conveyor belt so that it will not scrape solid material from the preheat zone onto the elements.
5. Making the preheat zone hotter and longer and exhausting it more effectively.

J. P. LYLE, Jr.



## THIS is No Ordinary Power Hack Saw Blade

This is the *unbreakable* MARVEL High-Speed-Edge Hack Saw Blade—the first bi-metal blade—invented, developed and introduced by MARVEL. This blade is a combination of two materials best suited to the requirements of an efficient hack saw blade . . . a narrow high speed steel cutting edge permanently welded to a tough, non-brittle alloy steel body. Each blade is triple tempered to assure long life and maximum toughness to the cutting edge.

With a MARVEL Blade, you can cut any material—from the free machining steels to the toughest alloys . . . fast, accurately and economically.

You can tension a MARVEL Blade from 200% to 300% tauter than any ordinary blade, permitting much higher speeds and heavier feeds without deflection or breakage.

Like all good things, attempted copies of the MARVEL Blade have been numerous, but its performance has been *unequaled* by any of the imitators. Ask for MARVEL Blades by name and you can be sure you're getting the best on the market. Leading Industrial Distributors have them in stock.

Write for latest cutting tool Bulletin and the name of your nearest MARVEL Distributor.

FB-1020



ARMSTRONG-BLUM MFG. CO. 5700 W. Bloomingdale Ave., CHICAGO 39, U.S.A.

# FAHRITE

HEAT AND CORROSION *Alloys*

## CENTRIFUGALLY-CAST TUBES



Centrifugally-cast Fahrte alloy tubes for roller shaft assemblies, tubular furnace hearths and radiant heating installations. Many sizes of Fahrte tubes can be centrifugally-cast from Ohio Steel's permanent mold equipment. Fahrte U-bends also are available for use with tubes in radiant heating installations. Centrifugally-cast tubes are available in many grades of Fahrte to meet your exact operating conditions.



THE OHIO STEEL FOUNDRY CO.  
SPRINGFIELD, OHIO

Plants at Springfield and Lima, Ohio

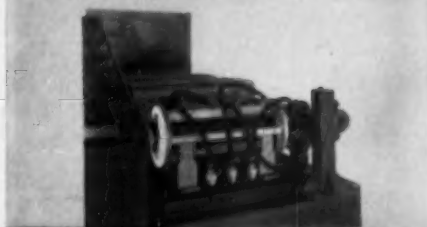
OFB

# AJAX...for complete induction heating-melting systems

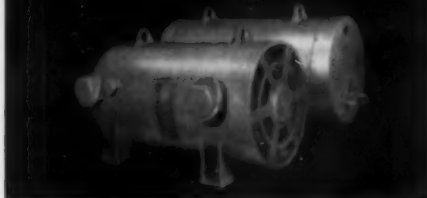
**FURNACE**



**HEATERS**



**POWER**



**CONTROLS**



Behind every induction furnace there must also be a source of power and a means of controlling that power. While the characteristics of any one of these three elements limits the selection of the other two, there are no hard and fast rules to follow when designing a complete system. Only experienced specialists can effect the perfect match which alone assures you all the advantages induction methods can provide.

You can get some idea of the breadth of choice which exists when planning a system from the general descriptions below. For further details, write Ajax Electrothermic Corporation, Trenton 5, New Jersey.

## FURNACE

**Tilting Type:** Usually chosen for ferrous metals and larger charges of non-ferrous metals. Close coupling between coil and charge makes for high efficiency. Double trunnion keeps spout close to mold.

**Lift-Coil Type:** For non-ferrous metals in charges to 300 lbs. Inductor coil lowered over charged crucible; raised after charge melts; lowered over second crucible. Highly flexible.

**Vacuum and Pressure Type:** Wherever exceptionally high purity is required. Custom designed for charges from a few pounds to over 1000 lbs. (steel).

**Special Types:** AJAX has often drawn on its long experience to design and construct numerous furnaces and crucibles of special sizes and shapes and materials.

## HEATERS

**General Purpose:** Inductors can be designed for any induction heating job. Inexpensive heaters can easily be interchanged for various load sizes and shapes. Special inductors are available to focus heat for forging, brazing, hardening, soldering, etc.

**Carbides:** These special furnaces for making and hot-working carbides are usually equipped with graphite crucibles or sleeves, able to withstand very high temperatures. Units are available for hot-pressing carbides in vertical or horizontal presses.

## POWER

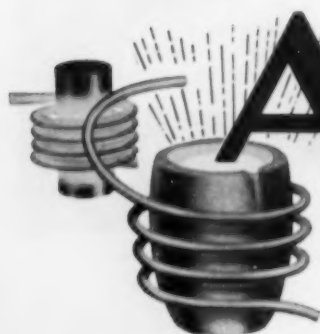
**Motor Generators:** Used for most large production heating and melting jobs. Available at frequencies from 1 to 10 kc, with output from 30 to 1250 kw and up.

**High Frequency Converters:** Spark gap converters used in laboratories and for small production jobs. Self-tuning. Frequency range from 12 to 60 kc, at power ratings of 6, 20, and 40 kw.

## CONTROLS

All controls for an AJAX installation are grouped in one convenient location. Complete instrumentation permits even a relatively unskilled operator to keep the furnace at top efficiency. The panel shown controls a motor generator set. Converter controls are generally more simple, and are mounted on the converter cabinet.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.



# AJAX


NORTHERN

SINCE 1916



## INDUCTION HEATING-MELTING

# KNOW... the growing metal

plan to attend  
the  titanium conference  
during the Western Metal  
Exposition  
Hotel Ambassador, Los Angeles

March 25 through 29, 1957

## SUBJECTS TREATED BY TOP AUTHORITIES

From comprehensive lectures and discussions on the latest known techniques, you can gain a wealth of practical knowledge that is so greatly needed today. The following subjects make this a great course on TITANIUM—short, intensive, and of real value.

### • CURRENT STATUS

Sponge Production Techniques — Guarding against Contamination — Uses of Titanium in Airframes, Missiles, and Jet Engines — Economic Aspects

### • CASTING AND ALLOYING

Vacuum Melting—Effect of Alloying Elements — Present and Future Alloys

### • MECHANICAL METALLURGY

Strength—Ductility—Yield Properties—Effects of Temperature and Strain Rate

### • FUNDAMENTALS OF HEAT TREATMENT

Open Air Treatment—Vacuum Heat Treating—Embrittlement—Degassing—Annealing—Stress Relief — Equilibria—Kinetics — TTT Curves — Metallography

### • MACHINING AND GRINDING

Titanium's Affinity for Other Materials and Possible Machining Difficulties—How to Overcome Them—Machines and Tools Involved—Effects of Alloying on Machinability—Chem-milling

### • CORROSION RESISTANCE

Principles and Applications

### • WELDING

Welding Characteristics—Problems and Techniques

### • FABRICATION PROBLEMS

Hot and Cold Fabrication—Steps and Processes—Economic Factors

### • DESIGNING WITH TITANIUM

Uses of Formed Sheet—Forgings—Limitations of Castings—Honeycombed Structures—Powder Metallurgy Products

Titanium—a comer among metals—versatile—possessing many highly desirable qualities, yet costly and temperamental—presents unique opportunities and challenging problems. The high demand for titanium and its alloys in many forms is impressive—promises increased growth as production techniques improve and costs are reduced.

## A CHALLENGE AND REWARD FOR MEN WHO KNOW

To meet the unique problems of titanium production and processing calls for a high degree of understanding of mechanical working, yield characteristics, and ductility, as well as the effects of alloying and heat treatment on the metal's behavior. Though many fabrication techniques may already be known, there's still much to learn. Something new is always ahead, so plan to attend the Titanium Conference and UPDATE YOUR THINKING!

## THE LATEST AUTHORITATIVE INFORMATION QUICKLY AND AT LOW COST

To men who aspire to achieve in a new and promising field, the American Society for Metals, through its newly created Metals Engineering Institute, is conducting a five-day TITANIUM CONFERENCE in Los Angeles, March 25 through March 29, 1957. Top authorities will lecture, discuss, and instruct. It's an opportunity to get the latest information in minimum time—and at a cost of only \$125.00 for the entire course (including daily lunches and study materials).

Since registration is necessarily limited, DON'T DELAY. Enroll now or send for full information AT ONCE. Mail in the accompanying coupon TODAY.

### TITANIUM CONFERENCE

March 25-29, 1957

Metals Engineering Institute, Dept. MP  
7301 Euclid Ave.  
Cleveland, Ohio

Gentlemen:

- ☐ Enroll me; \$125.00 registration fee enclosed  
☐ Send me more information

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NEW G-E RESOTRON® 275  
*gives you:*

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Now G-E *progress* engineering provides "big machine" performance with portability . . . made possible by the *highest voltage* yet in a portable unit! Rated at 75 to 275 kvp, 2 to 10 ma, this unit makes shop, laboratory or field x-ray testing and inspection easier because:

- Compact resonant transformer design eliminates bulky iron core, uses gas insulation in place of conventional transformer oil.
- Multisection x-ray tube efficiently divides voltage into increments to minimize dielectric glass strain.
- True sine-wave output shortens exposure time.
- Beryllium window gives maximum x-ray contrast for light alloys.
- Two tubes — 360° and 45° targets for versatility. With 360° tube, radiographs of circumferential welds can be made in one exposure.



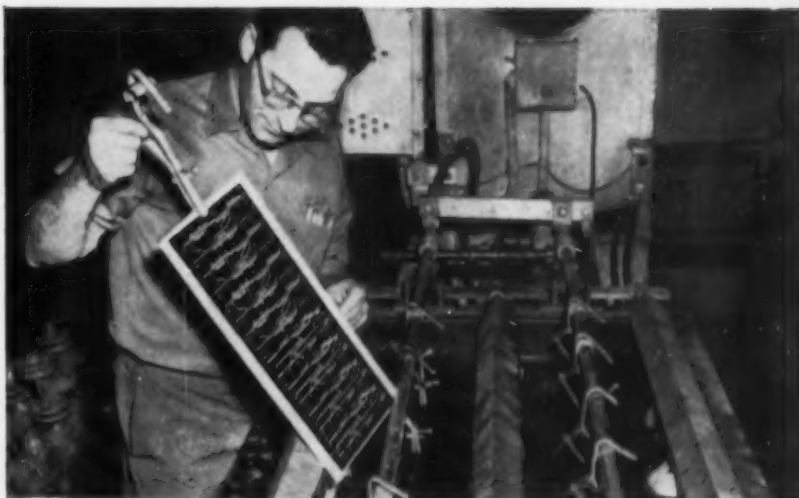
In addition to portable unit illustrated, the Resotron 275 is available for permanent installation, floor or ceiling mounting. Your General Electric x-ray representative can furnish complete details. Call him, or write X-Ray Department, General Electric Co., Milwaukee 1, Wis., for Pub. AS-10-4



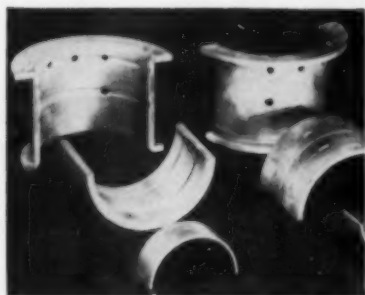
*Progress Is Our Most Important Product*

GENERAL  ELECTRIC

# How You Can PLATE Faster, Better



**PRINTED CIRCUITS**—Low cost, easily assembled printed circuits for radio and other electronic equipment may be plated economically and efficiently with B&A Copper Fluoborate and B&A Lead-Tin Fluoborates.



**PLATING VERSATILE LEAD-TIN ALLOYS**—Lead-Tin alloys of low tin content can be plated from the fluoborate bath to give excellent protective and lubricating coatings for vital engine parts and bearings.



**PLATING ELECTROTYPE SHELLS**—B&A Tin Fluoborate for plating electrotype shells prior to casting offers an easily controlled bath. A combination lead-tin bath has also been used successfully. The Copper Fluoborate bath is used for high speed forming of electrotype shells.



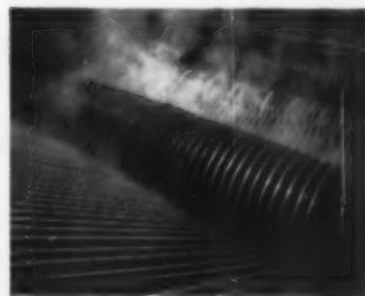
**EASILY SOLDERED COATINGS**—A high tin-content Lead-Tin Alloy Fluoborate Bath produces easily soldered coatings on electronic or electrical parts. The Tin-Fluoborate bath can also be used. These uniform deposits help expedite assembly.

The standout performance of B&A Metal Fluoborate Solutions in Lead, Tin, Iron, Copper, Nickel, Cadmium and Indium plating is news of greatest importance to platers. These B&A products permit far faster plating rates, and provide platers with a host of other advantages not available in any other plating agents!

In alloy plating, for example, they offer the only fast, efficient way to plate Lead-Tin and Lead-Tin-Copper alloys—simultaneously—at easily controlled ratios. In Cadmium plating, outstanding results are obtained

without the hydrogen embrittlement common to other methods. In Lead-Tin alloy plating, they produce coatings with excellent solderability that is not destroyed by aging. Other applications include high-speed copper-plating of plastics, copper-plating of steel wire and copper under-coatings prior to nickel plating.

For a descriptive folder, for experimental or commercial quantities, operating data—or for free technical consultation—write or phone your nearest B&A office.



**HIGH SPEED WIRE PLATING**—The fast plating rate of B&A Copper Fluoborate makes possible high-speed electrocladding of steel wire. And the Tin Fluoborate bath is used for high speed electro-tinning of copper wire.



## BAKER & ADAMSON® Fluoborate Solutions

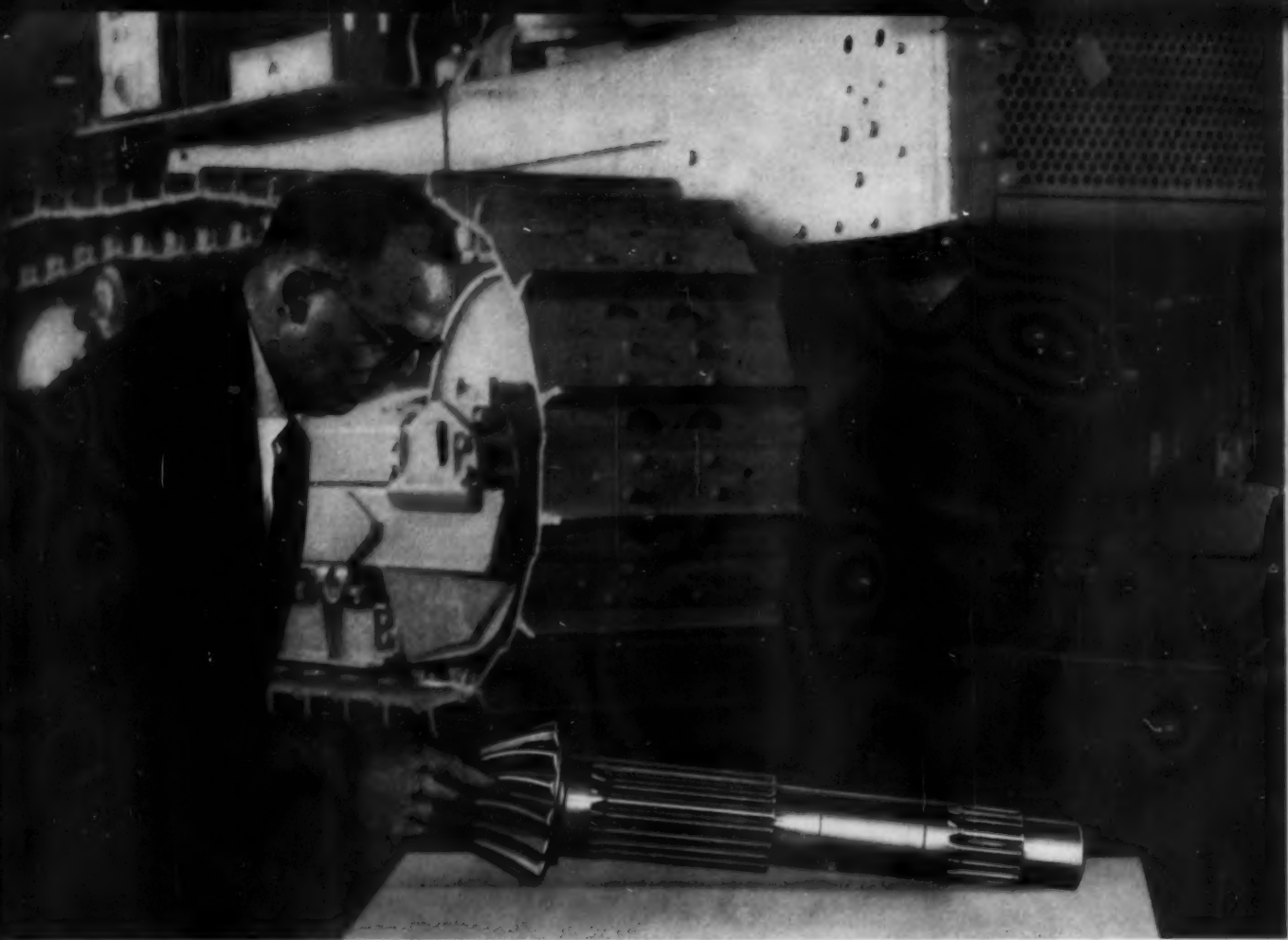
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Caterpillar Tractor Co. Metallurgist T. H. Spencer inspects final drive pinion for D9 crawler tractor weighing 28 tons. Severe loading of this large pinion requires a steel with high case and core hardenability. Several years ago

Caterpillar Tractor Co. found that simply by increasing the molybdenum content of AISI 8622 (to 0.30-0.40%), the desired properties were obtained at lower cost than was possible in any of the standard carburizing grades.

## Caterpillar Tractor Co. improves case and core hardenability of carburizing steel by increasing molybdenum content

"Drive pinions in tractors must take very high torque loads," says T. H. Spencer, Metallurgist for Caterpillar Tractor Co. "AISI 8622 steel, which we had been using, couldn't give us the hard case and strong, tough core we needed in these heavy sections. Other standard carburizing steels with the requisite properties would have cost substantially more. We found, however, that we could achieve the desired surface and core properties by simply modifying AISI 8622 with a higher percentage of molybdenum. We have been using this composition for several years, and results have been excellent."

Caterpillar Tractor Co.'s experience shows how increasing molybdenum in a carburizing steel helped to solve a specific problem. Perhaps your product, too, can benefit by higher molybdenum content.

A technical article, "New Carburizing Steels for Critical Gearing", describes some recent investigations of higher-moly carburizing steels. For a reprint, write Climax Molybdenum Company, Dept. 5, 500 Fifth Avenue, New York 36, N. Y.

# CLIMAX MOLYBDENUM



*Tear this chart out and preserve it*

## YOUR GUIDE TO COLUMBIA HIGH SPEED TOOL STEEL GRADES

TYPE AND GRADES	DESCRIPTION	HARDENING RANGE	QUENCH	TEMPERING RANGE	USEFUL HARDNESS
<b>T1 — CLARITE</b>	Standard type, high red hardness, good strength, wide range of use with high over-all efficiency	2000° F. to 2350° F.	Oil or Salt Bath	1000° F. to 1250° F.	65 /60 Rc
<b>T2 — VANITE</b>	Increased carbon and vanadium, best for form tools and finishing cuts	2300° F. to 2375° F.	Oil or Salt Bath	1000° F. to 1050° F.	66 /63 Rc
<b>T4 — ACMITE</b>	18-4-1 high speed steel with 5.00% cobalt added; for heavy cuts, all around high speed cutting with long life at high speeds.	2325° F. to 2375° F.	Oil or Salt Bath	1000° F. to 1025° F.	66 /64 Rc
<b>T5 — COBITE</b>	18-4-2 with 8.00% cobalt high speed steel, extreme red hardness, for hogging cuts on scale and hard abrasive materials	2325° F. to 2375° F.	Oil or Salt Bath	1000° F. to 1100° F.	66 /64 Rc
<b>T8 — MAXITE</b>	High carbon, high vanadium with 5.00% cobalt. High production steel for cutting hard castings and tough heat treated alloy steels	2325° F. to 2375° F.	Oil or Salt Bath	1025° F. to 1075° F.	66 /63 Rc
<b>M2 — MOLITE SMOOTHCUT</b>	Molybdenum-tungsten multipurpose high speed steel with smoothcutting additives for greatest economy	2100° F. to 2275° F.	Oil or Salt Bath	1000° F. to 1250° F.	66 /58 Rc
<b>M3 — MOLITE '3</b>	Molybdenum-tungsten high speed steel with higher carbon and vanadium for fine cuts including broaching and reaming	2175° F. to 2250° F.	Oil or Salt Bath	1000° F. to 1100° F.	66 /63 Rc

COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILLINOIS 1957  
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Phone MA 6766 1-1783

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121 Oakman Blvd.  
Phone TU 6766 3-3770

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6955 E. Bendish Blvd.  
Phone RA 6766 3-4664

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## COLUMBIA TOOL STEELS

DIE STEELS: Superdie — Almodie — E-Z-Die Smoothcut — Ex-L-Die — CEC Smoothcut HOT WORK STEELS: Clarite HW — Formite #3 — Mollite HW10 — Vanadium Firedie — Alcodie — Firedie CARBON TOOL STEELS: Columbia Special — Vanadium Extra — Waterdie Extra — Columbia Extra Headerdie — Vanadium Standard — Columbia Standard



# *Western Metal Exposition*

**PAN-PACIFIC AUDITORIUM**  
**Los Angeles, California**  
**MARCH 25 through 29, 1957**

**RESERVE YOUR  
EXHIBIT SPACE NOW!**

Metals industries people—ready and able to buy the things they want and need to make things of metal—will be pouring into this great Western Metal Show and you'll want to be there . . . be there with your products on display and your sales staff on its toes, because you'll sell—and sell often—at this great concentration of metals industries people! Remember, more of your customers and prospects will see this Western Show than ever before!

*An activity of the*  
**AMERICAN SOCIETY for METALS**

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Managing Director  
W. H. EISENMAN

Assistant Director  
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200-B



METAL PROGRESS

# uniform HEAT for BIG jobs!



**at morgan engineering-alliance, ohio**

This 52' x 21 1/4' x 17 1/2' high car bottom furnace was designed by Morrison Engineering to stress relieve heavy weldments. The furnace is available for use by other firms on a subcontracting basis. It has the second largest car bed area of any such furnace in the world.

Imagine getting a uniform heat throughout a 250,000 pound load of steel with 3" to 10" thick sections in such a huge furnace! 48 North American No. 223-4 Dual-Fuel Burners do the

trick. These burners, arranged in 4 banks and 3 zones, can burn 250 gallons of oil per hour, releasing 33 million Btu. They maintain a stable fire even when operating with a large amount of excess air to attain good temperature uniformity.

All the air is supplied by a North American Turbo Blower. North American pilots, valves, and Ratiotrols provide a safe, effective control system.

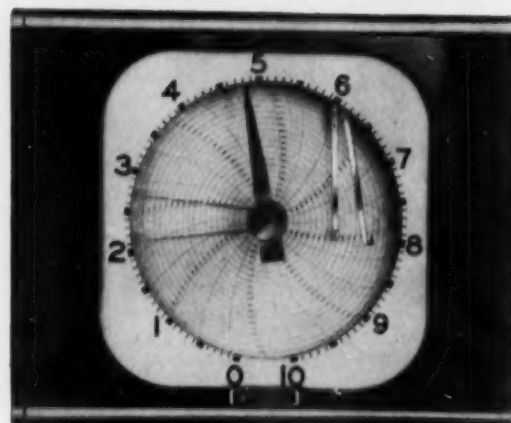
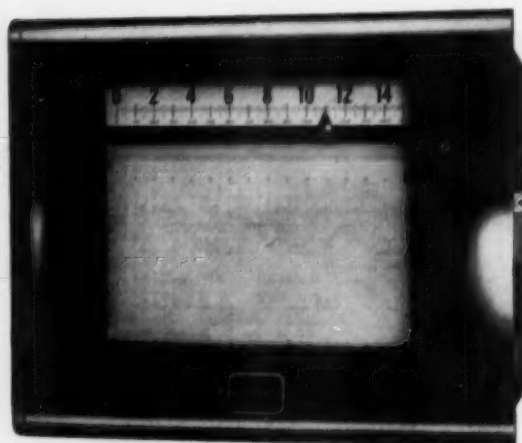
**for additional information consult your local n. a. engineer or write for bulletin 223**



the **NORTH AMERICAN** mfg co

*Combustion Engineers*

4455 East 71st St. • Cleveland 5, Ohio



## Three reasons temperature control is better with Bristol

**FIRST TWO REASONS** are Bristol's Electronic Dynamaster Potentiometers with strip chart or round chart. Here's why:

**No-Batt Continuous Standardization** in these instruments eliminates need for dry cells. Result: No interruption in operation for standardization, no batteries to replace.

**Recorders for every requirement** — single-pen, two-pen, and multiple-record (up to 24 points)

**Electric and pneumatic controllers** for every furnace and oven control mode, including *electric controllers* for on-off, proportional-input, 3-position, proportional, proportional plus automatic reset, and time-program control; and *pneumatic controllers* for on-off, proportional, proportional plus reset, and proportional plus reset plus derivative control.

**THIRD REASON:** Bristol's Free-Vane® Electronic Pyrometer Controller. No relay chatter with this controller! Bristol's thyatron-operated relay puts a stop to that. Minute changes in temperature — less than 0.003" on scale — close or open the relay with positive trigger action. Available in thermocouple and radiation pyrometer controllers in ranges up to 4000F. New high-torque, rugged millivoltmeter gives greater accuracy and a sensitivity of 15 ohms per millivolt. Separate plug-in control units, variety of control modes available.

Get the whole story on these three rugged Bristol Furnace and Oven Controls. Write for free 48-page Bulletin P1260 today. It contains specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 106 Bristol Road, Waterbury 20, Conn.

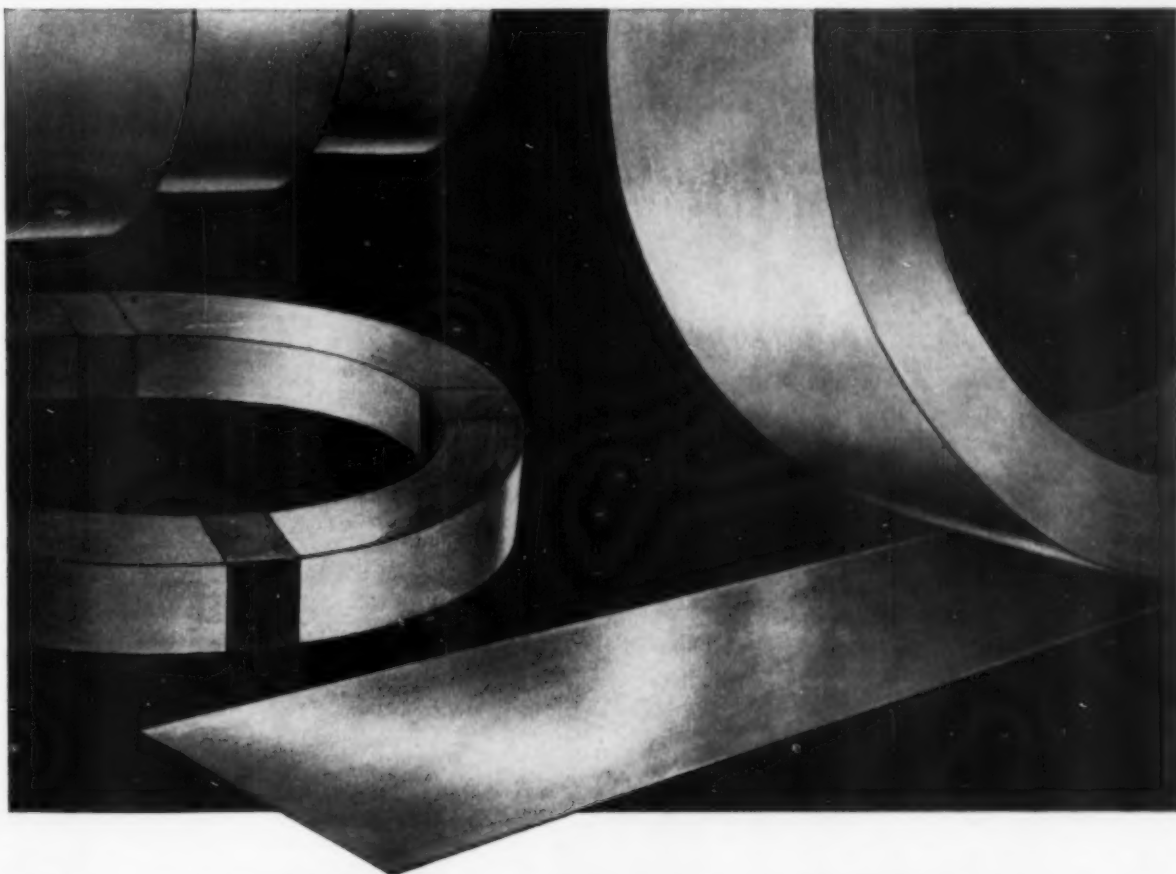
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# BRISTOL

POINTS THE WAY IN  
HUMAN-ENGINEERED INSTRUMENTATION

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**BRISTOL'S**  
REGISTERED

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS



## Superior Quality, Retained in YOUR Product ... UDDEHOLM Strip Steel

Quality of materials is something that will always show up in the final product. So why not take advantage of the extra quality available in Uddeholm Swedish Strip Steel. For, besides transferring its inherent quality to your product, such a steel can seriously lessen production problems and rejects.

Reasons for Uddeholm Strip Steel "quality" are easy to explain. As a raw material Uddeholm uses famous Varmland iron ore, world-renowned for its exceptional purity. Added to this is a traditional craftsmanship in steelmaking almost three centuries old—where only the finest steel is accepted. Final perfection is guaranteed by a selective system of rigid inspection.

In terms of your application, then, this means cold-rolled strip steel of consistent uniformity, undeviating flatness, and fine finish—with straightness of edges and accurate dimensional tolerances throughout. And these features are combined in the grade, finish and dimensions you need, whatever your requirements. Widths range from  $\frac{1}{8}$ " to  $16\frac{1}{4}$ ", thicknesses from .001" to .125". Tolerances as close as  $\pm .00008$ " are possible. Slitting and edging facilities are also available.

Uddeholm Strip Steels appear in countless applications, including Stainless Steel products, stampings, intricate machine parts, all types of blades and springs, and many others. For quick delivery just phone us your needs.

Write for latest Strip Steel Stock List



### UDDEHOLM COMPANY OF AMERICA, INC.

Tool and Die Steels  
Specialty Strip Steels

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Warehouses

New York: 155 East 44th Street, MUrray Hill 7-4575  
Cleveland: 4540 East 71st Street, DIamond 1-1110  
Los Angeles: 5037 Telegraph Road, ANgelus 2-5121

District Representatives

CHICAGO: Frank J. Mackin, Leroy E. Marshall, 55 East Washington, STate 2-1649

DETROIT: Warren H. Nugent, 17304 Lahser Road, KEnwood 5-6340

In Canada: Uddeholm (Canada) Ltd.

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National Bureau of Standards  
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Firth Sterling  
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U.S. Dept. of Agriculture  
Colorado School of Mines  
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American Brass  
Minneapolis-Honeywell Regulator  
Procter & Gamble  
Glenn L. Martin Co.  
E. I. DuPont de Nemours  
International Business Machines  
National Cash Register Corp.

## THIS COMPLETE CATALOG ON UNITRON MICROSCOPES IS YOURS FOR THE ASKING



This colorful, illustrated catalog gives complete specifications on all of the instruments briefly described on this page, as well as others which we know will interest you. Send coupon below for your free copy.

**UNITRON** INSTRUMENT DIVISION OF  
UNITED SCIENTIFIC COMPANY  
204-206 MILK STREET - BOSTON 9, MASSACHUSETTS

Please send us your complete catalog on  
UNITRON Microscopes.

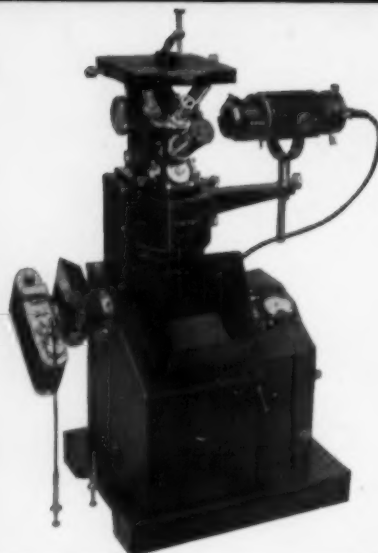
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Company .....

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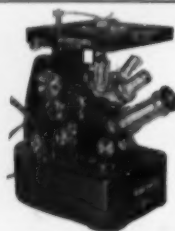
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### UNITRON METALLOGRAPH and UNIVERSAL CAMERA Microscope, New Model U-11

- For visual observation, measurement, and photography of both opaque and transparent specimens.
- Bright field, dark field, and polarized illumination.
- Revolving nosepiece with 8 objective lenses, 4 photographic eyepieces, 3 visual eyepieces. Coated optics. Magnification range: 28-2900X.
- Compact and entirely self-contained with built-in 3 1/4" x 4 1/4" camera, high-intensity illuminator, variable transformer.
- The image is automatically in focus in the camera—transition from observation to photography is instantaneous.
- Transmitted light accessories for transparent specimens included.
- Calibrated square mechanical stage with calibrated rotatable stage plate.
- Many other important features and accessories including calibrated polarizing apparatus, filters, micrometer eyepieces, film holders, etc. Cabinet.
- Additional accessories include: Polaroid Land Camera attachment; 38 mm camera attachment; low-power (5-60X) objectives; available at extra cost.

COMPLETE UNIT only **\$1145.**  
fob Boston  
BINOCULAR MODEL, BU-11 only \$1319.



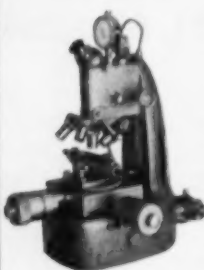
### UNITRON Model MEC

is of the inverted type and designed for visual observation of metals, ores, minerals, etc. It includes many of the features of the Model U-11 Metallograph which are connected with visual observation of opaque specimens. 25-1500X.

- transformer built into microscope base,
- vertical illuminator with iris diaphragm.
- coarse and fine focusing.

- filters: polaroid, frosted, blue, green, yellow.
- large mechanical stage with graduated circular rotatable stage plate.
- calibrated polarizing apparatus.
- coated optics
- revolving nosepiece with objectives 5X, 10X, 40X, 100X oil.
- eyepieces: PSX, Micrometer 10X, K15X.

COMPLETE only **\$319.**  
fob Boston  
Binocular Model, only \$493.



### UNITRON TOOLMAKERS and METALLURGICAL

UNITRON Model TM combines in one stand a toolmakers microscope for precise shop measurements of either opaque or transparent specimens and a metallurgical microscope for the high-power examination of polished metal specimens. Note the many features of this versatile instrument.

- combination rectangular 1" x 1" ball bearing stage and circular rotary stage
- large micrometer drums read directly to 0.0001"
- dial indicator measures depth, reading to 0.0001"
- substage illuminator for viewing projects
- surface illuminator
- vertical illuminator for examining grain structure
- transformer built into base
- inclinable tool holder
- coarse and fine focusing
- revolving nosepiece with objectives: 3X, 10X, 40X. Crosshairs eyepieces, 10X.

Complete only **\$1050.**

### UNITRON MODELS MMU and MMA

These popular laboratory microscopes are ideal for the examination of both metal and transparent specimens under both ordinary and polarized light. In addition to providing vertical incident light, the illuminator may be mounted directly on the stage for oblique lighting and below the stage for transmitted light. The transformer is located conveniently in the microscope base. These models include features found only in instruments selling for over twice our unusually low prices.

#### MODEL MMU

- coarse and fine focusing
- focusable stage
- calibrated drawtube
- revolving nosepiece—objectives 5X, 10X, 40X, 100X oil
- eyepieces: PSX, P10X, K15X

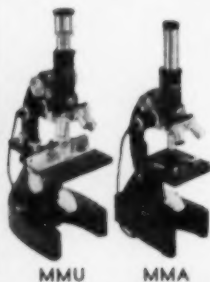
Complete **\$287.**  
only

#### MODEL MMA

- single focusing control
- revolving nosepiece with objectives 5X, 10X, 40X
- eyepieces: MSX, P10X, K15X

Complete **\$149.**  
only

All microscope prices are subject to change without notice.



MMU

MMA

**UNITRON**

INSTRUMENT DIVISION OF  
UNITED SCIENTIFIC COMPANY

204-206 MILK STREET - BOSTON 9, MASSACHUSETTS



reports on

## "SOLUTION CERAMICS"

### WHAT THEY ARE

Coatings of "Solution Ceramics" provide a thin insulating film relatively inert and highly refractory with excellent resistance to thermal shock.

They are obtained when thermal decomposition of atomized ceramic solutions is completed just as the residual particles strike the heated surface to be coated. Methods used depend upon the shape of the surfaces, its heat capacity and thermal conductivity. These processes were developed by the technical staff of the Armour Research Foundation of Illinois Institute of Technology.

### RESULTS TO DATE

Field development work, as per agreement with the Foundation, is being conducted by the field engineering staff of TAM. Industrial trials, to the present time, indicate the most likely and advantageous uses in the fields of electrical insulation, inert casting, linings for cartridge cases and as a plate surface for lithographic reproduction.

### HOW TO OBTAIN FURTHER INFORMATION

Specific, technical or license information may be had upon request to TAM's N.Y.C. offices.

### TITANIUM ALLOY MFG. DIVISION

#### NATIONAL LEAD COMPANY

*Executive and Sales Offices:*

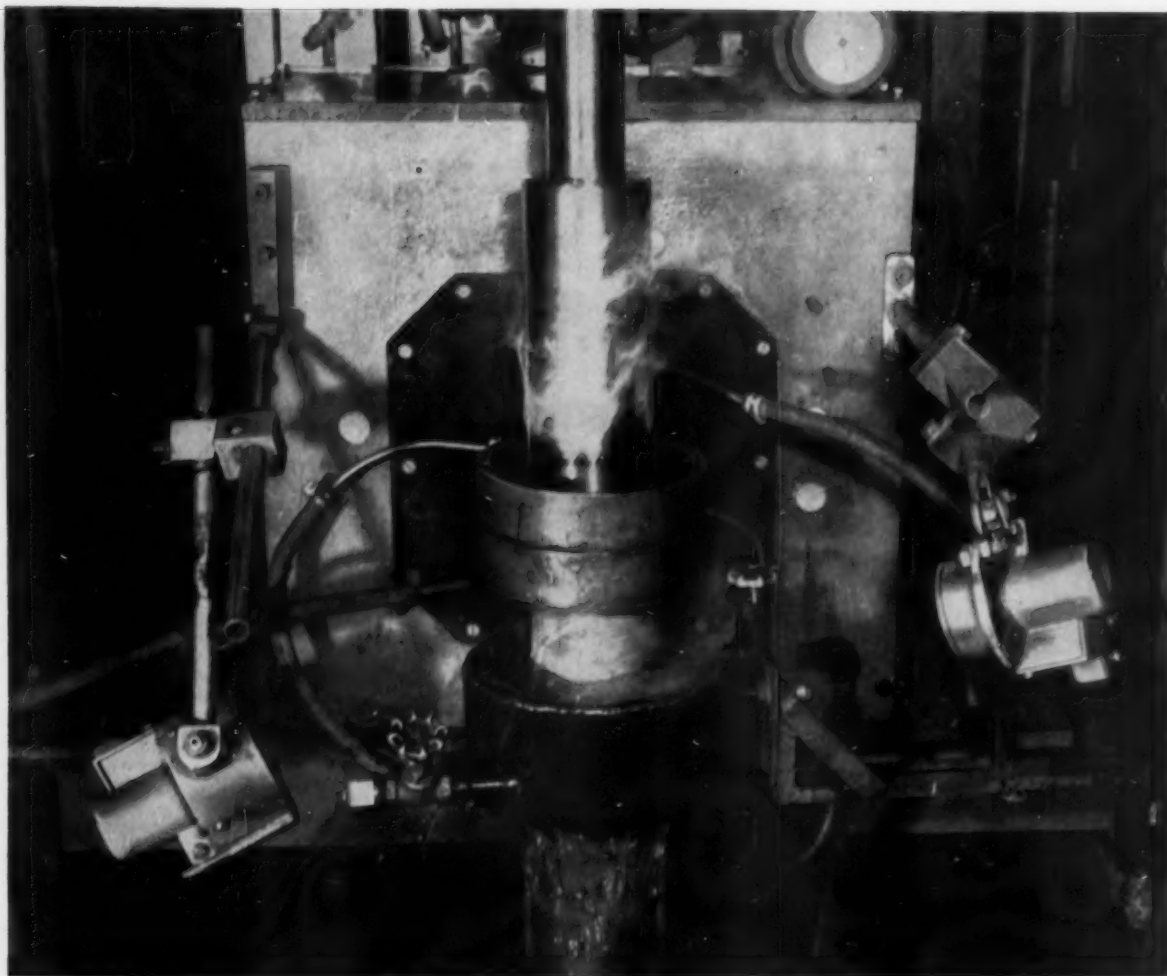
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*General Offices,*

*Works and Research Laboratories:*

Niagara Falls, New York





## Soaking up heat radiation...

... these two L&N Rayotube® detectors are helping McKay Machine Company induction-harden bodies of leveller rolls. About four years ago, this manufacturer of sheet, tin and strip mill equipment switched to full time induction hardening of these shafts which range from  $\frac{7}{8}$ " to 12" in diameter and up to 12' long. The new method doubled production . . . eliminated warpage . . . and provided scale-free hardening. And, in addition, the use of L&N temperature control enabled the McKay Machine Co. to reduce setup time . . . eliminate trial runs . . . and produce the same results heat after heat.

The temperature regulating equipment con-

sists of Speedomax®-Rayotube control on each of two 3000-cycle induction generators having a maximum capacity of 400 kw. One Speedomax in combination with a Rayotube detector controls work temperature by operating a motor-operated rheostat to regulate power input to the induction coil. For quality control, a second Speedomax-Rayotube combination measures and records quench temperature while a third Speedomax provides a record of work speed through the coil.

To find out how L&N temperature control may help increase the efficiency of your induction heating, contact your nearest L&N sales office or write 4927 Stenton Ave., Phila. 44, Pa.

**LEEDS**  **NORTHROP**  
Instruments Automatic Controls • Furnaces



A few of the thousands of crankshafts produced at National Forge for new diesel engines.

## HAVE YOUR CRANKSHAFTS RECONDITIONED BY A FIRM EXPERIENCED IN MAKING ORIGINAL CRANKSHAFTS

National Forge has been making crankshafts for diesel engines for many years... starting with our own basic electric steel and ending with a shaft ready to install in original equipment, we have a wealth of "know-how" regarding crankshafts.

Recently, National Forge has added a new crankshaft reconditioning division. This includes a large chromium plating department and additional grinding, straightening, and inspection equipment for handling crankshaft reconditioning on a production line basis.

National Forge's large modern facilities and years of experience in producing new crankshafts assure you of proper handling and good workmanship on your reconditioning jobs.

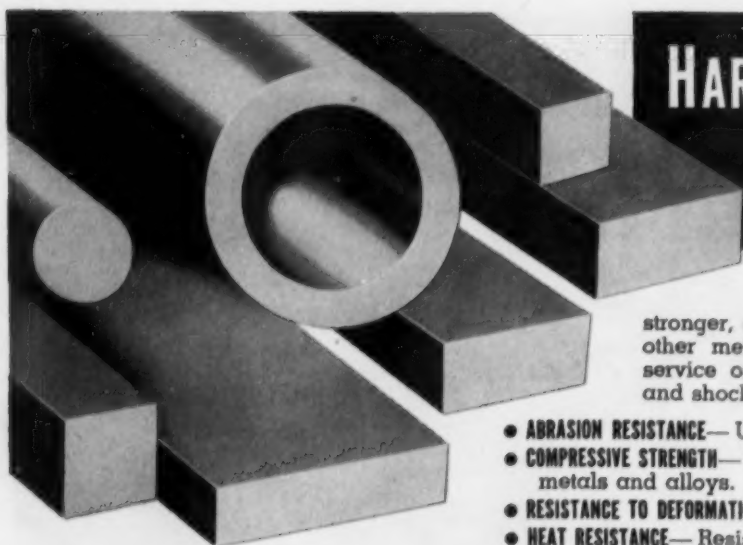
We will be glad to have our field representative call on you to discuss your needs.



**NATIONAL FORGE AND ORDNANCE COMPANY**

PRODUCES BETTER STEEL FORGINGS AND MACHINE WORK

IRVINE, WARREN COUNTY,  
PENNSYLVANIA



## HARDEST MAN-MADE METAL

TALIDE METAL, a tungsten carbide of superior quality, is harder, stronger, and more resistant to abrasion than any other metal. Properly applied, it gives superior service on applications where wear, heat, strain and shock are destructive to other metals.

- **ABRASION RESISTANCE**—Up to 100 times that of steel.
- **COMPRESSIVE STRENGTH**—Higher than all melted, cast or forged metals and alloys.
- **RESISTANCE TO DEFORMATION**—2 to 3 times greater than steel.
- **HEAT RESISTANCE**—Resists oxidation and thermal shock up to 1500° F.
- **THERMAL EXPANSION**—Less than half the rate of steel, "creep" is negligible.
- **FRICTIONAL RESISTANCE**—Lower than steel, non-galling, "slippery" properties higher.

TALIDE METAL is saving industry millions of dollars annually by wear-proofing vital parts on machine tools, presses, pumps, compressors and other types of processing equipment used in the steel, oil, chemical, plastic, auto, rubber, textile, glass, mining and metal-working industry. The physical properties of the most commonly used grades are listed below. Other grades are available for specialized applications.

### PHYSICAL PROPERTIES OF TALIDE METAL (P. S. I.)

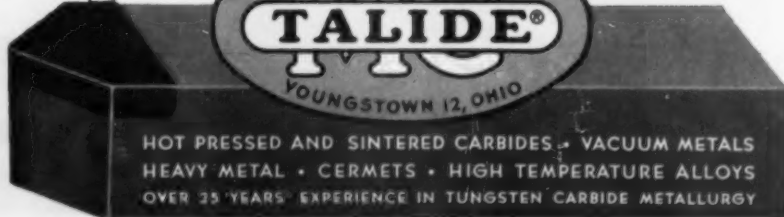
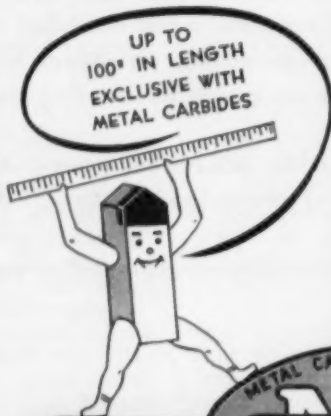
Application	Operation	Talide Grade	Rockwell "A" Hardness	Specific Gravity (Density)	Transverse Rupture Strength	Compressive Strength	Co-Efficient of Thermal Expansion	Modulus of Elasticity (Deflection)
WEAR SURFACE	No Shock	C-91	91.8	14.90	235,000	710,000	$3.00 \times 10^{-6}$	91,000,000
	Light Shock	C-89	91.0	14.75	265,000	670,000	$3.65 \times 10^{-6}$	84,000,000
	Medium Shock	C-88	89.5	14.55	295,000	635,000	$4.00 \times 10^{-6}$	80,000,000
IMPACT	Light	C-85	88.4	14.25	315,000	600,000	$3.75 \times 10^{-6}$	77,000,000
	Medium	C-80	87.0	13.85	335,000	550,000	$4.50 \times 10^{-6}$	74,000,000
	Heavy	C-75	85.0	13.15	355,000	500,000	$5.00 \times 10^{-6}$	70,000,000

Note: Hardness values may vary plus or minus .2 to .3 on individual lots.

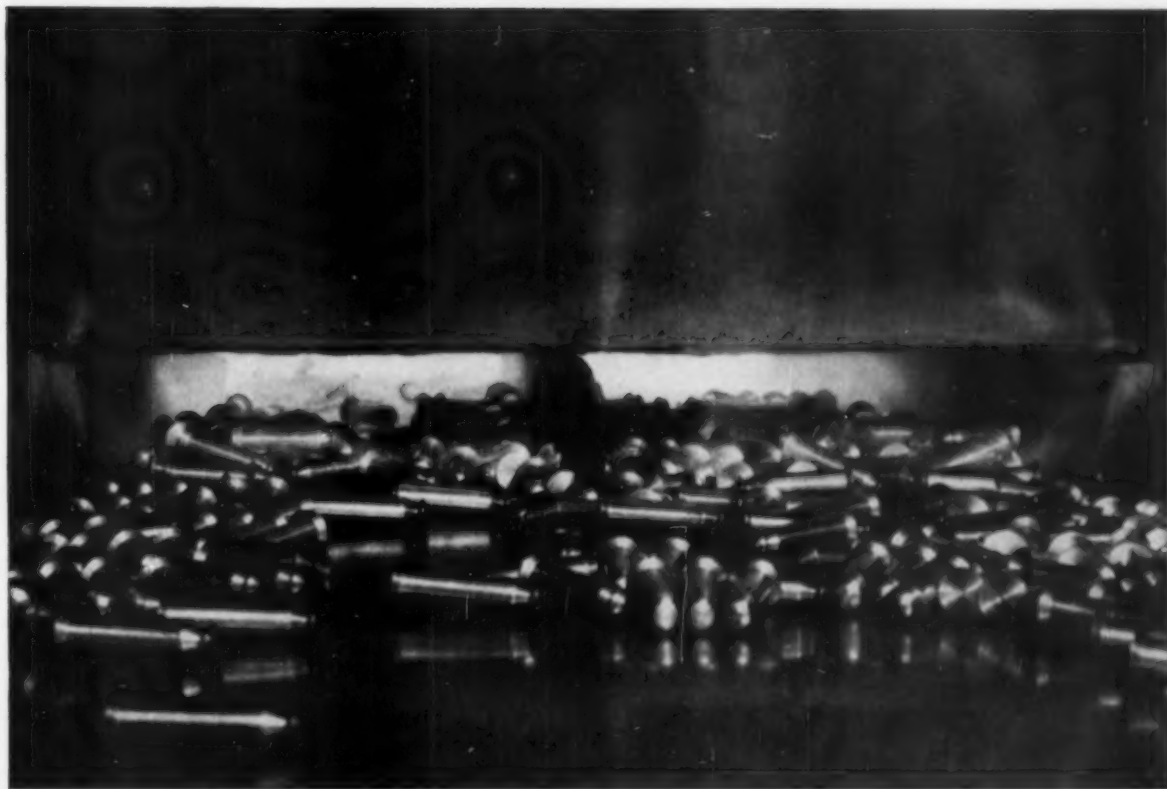
All TALIDE METAL grades are made in latest type vacuum electric furnaces by precision methods under rigid control. A wide variety of shapes and sizes can be supplied—up to 25" in diameter, 100" in length, and 5000 pounds by weight. Parts can be supplied to any grit finish required down to one micro-inch.

Metal Carbides Corporation,  
Youngstown 12, Ohio.

Send for new 76-page catalog  
56-G or ask for sales  
engineer to call.



HOT PRESSED AND SINTERED CARBIDES • VACUUM METALS  
HEAVY METAL • CERMETS • HIGH TEMPERATURE ALLOYS  
OVER 25 YEARS' EXPERIENCE IN TUNGSTEN CARBIDE METALLURGY



## No More Scaling Here..... Despite Severe Oxidizing Conditions

A vibrating chute made of a HAYNES high-temperature alloy solved a tough maintenance problem in this heat-treating furnace. The chute spans the entrance to the furnace and is subjected to severe oxidizing conditions. Other chutes became loaded with heavy scale in a few months' time and had to be repaired or replaced. Now that the chute is made of a HAYNES high-temperature alloy, there is no more scale. Parts keep flowing along freely, rejections are way down, and maintenance has been practically eliminated.

There are 11 HAYNES high-temperature alloys. All have excellent strength at elevated temperatures, good creep and stress-rupture properties, and are extremely resistant to oxidizing or reducing atmospheres. One of them may be the answer to a production or maintenance problem in your plant.

For information on prices, sizes, and properties of these alloys, write to our general sales office in Kokomo, Indiana, or to any of the district sales offices listed below.



### HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation



General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.



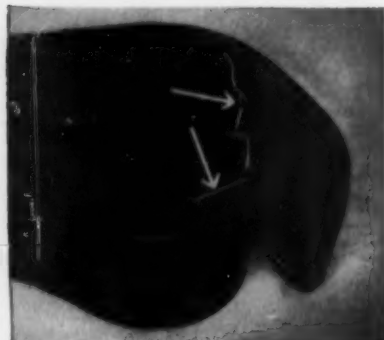
**WATCHING YOUR WEIGHT** can be important—especially in the aircraft industry. Excess weight can reduce the range and payload of a plane. A major aircraft manufacturer uses M Sonizon units to ultrasonically measure thickness of sheet and formed shapes. This controls weight by eliminating excessive thickness.

## Case Studies: NONDESTRUCTIVE TESTING SYSTEMS



Magnaglo and "black light" show up cracks as glowing indications on rough castings at a Peoria, Illinois foundry.

## How Nondestructive Testing Helps You Make Better Products . . . Cheaper



**HEAT CRACKED THE JAW**—The jaws of steel strapping machines must be reliable. Yet, following the heat treating, invisible cracks were discovered with Magnaglo as shown above. Immediate correction of the heat treat cycle eliminated the cracks. No further machine time or labor was expended on defective jaw parts, since none were made, and none scrapped!!

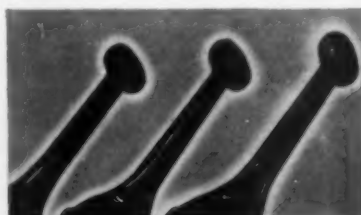
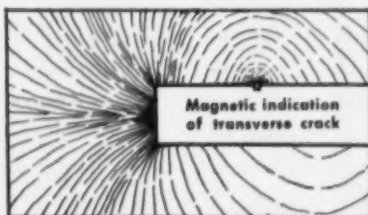
Most manufacturers can achieve definite, worthwhile savings by using one of the M testing systems for improved production control. These nondestructive inspection methods include: Magnaflux, for wet or dry magnetic particle inspection; Magnaglo, fluorescent particle inspection; Magnatest, eddy current electronic testing; Zyglo, fluorescent penetrant inspection; Spotcheck, dye penetrant inspection; Sonizon, for ultrasonic measurements; and others.

The M testing systems are equally effective for preventative maintenance or manufacturing inspection.

Most manufactured products contain one or more types of casting, forging weld-

ment, machined or formed part. Where cracks cannot be tolerated in the final product, maximum production economy must be obtained from the very outset. Defects must be discovered as early as possible in order to eliminate wasted effort in final processing or assembly.

Magnaflux methods pinpoint early defects, and help you eliminate their cause. This results in savings of time, labor and additional long range benefits from increased salvage and reduced amounts of scrap. For detailed information as to how one of the M inspection methods can help you produce better and save more, write or call for an interview with a Magnaflux engineer. No obligation, of course!



### HOW MAGNETIC FORCE DETECTS MECHANICAL DEFECTS

M nondestructive testing is based upon simple magnetic principles. A part to be tested is first magnetized—then magnetic powders or fluorescent particles in oil are applied. Surface defects

cause a break in the magnetic field—local magnetic poles cause particles to be held on part to mark extent of defect. Above—a Magnaglo indication on truck connecting rods.

HALLMARK  
OF QUALITY IN  
NONDESTRUCTIVE  
TEST SYSTEMS



Write for complete details concerning any of the above case studies, or ask for our new booklet on "Lower Manufacturing Costs."

### Take Your Inspection Problems to the House of Answers **MAGNAFLUX CORPORATION**

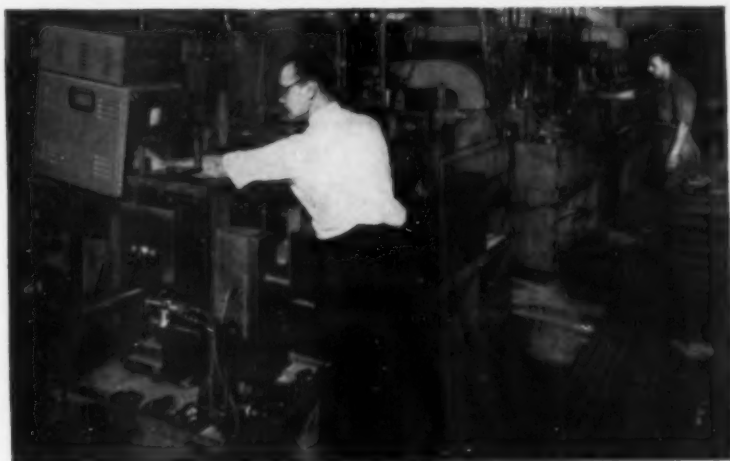
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METAL PROGRESS

**Sperry**

## ultrasonic inspection news

### AUTOMATIC INSPECTION AND CONTROL ON CONTINUOUS PRODUCTION LINE



Continuous inspection of steel tubing and strip at production speeds is now an accomplished fact with the new Sperry Ultrasonic Reflectoscope® and RA attachment. This unit scans material traveling at high speeds and registers the presence of both internal and surface defects. Far more thorough than the human eye, it provides for both defect recording and signaling in addition to continuous inspection. Designed to incorporate signal lights or alarm bells, as well as automatic marking and machine cut-off units, the Sperry Reflectoscope and RA attachment is a flexible, accurate instrument which opens a new area to more effective cost-cutting quality control.

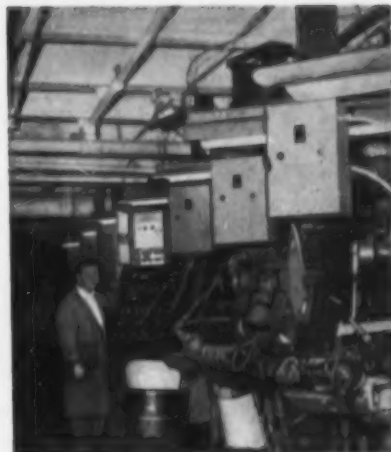
**sperry products INC.**

FIRST IN ULTRASONIC INSPECTION

DANBURY, CONNECTICUT



To keep posted on latest developments in the profitable use of ultrasonic inspection by industry send for your copy of our new Ultrasonic Inspection News Letter.



### Electronic Protectron Senses Overloads— Minimizes Press Damage

A punch press attachment, which detects the slightest overloads caused by pile-ups, misfeeds, tool dullness, misalignment, the Sperry Protectron minimizes tool and die damage by warning signals and actuation of control devices. The Protectron also cuts costly equipment damage and keeps all automatic machines running without close attention. With Protectron on guard, one man can safely and easily operate several machines at once.

Sperry Products, Inc.  
Shelter Rock Road  
Danbury, Connecticut

- ☐ Send me the Ultrasonic News Letter  
☐ Send me Reflectoscope information  
☐ Send me Protectron information

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**The Heart of the New, Low Nickel,  
High Manganese Stainless Steels...**

## **Foote ELECTROMANGANESE®**

Design engineers and metallurgists are capitalizing on the proven superiorities of the new, low cost manganese stainless steels. From gleaming railroad car exteriors, and automobile parts and trim . . . to sanitary, easy-to-clean kitchen equipment and deep drawn utensils, the uses of these high manganese steels are constantly growing.

Originally conceived as promising substitutes for the Cr-Ni steels, types 201 and 202 stainless steels in many applications are proving better than the classic 17Cr-7Ni or 18Cr-8Ni grades. High purity, low cost ELECTROMANGANESE® is the key to 200 series stainless as well as other steels requiring critical control of carbon and other elements.

Companion product to ELECTROMANGANESE® is Foote's nitrated manganese, NITRELMANG®. A convenient and stable source for major nitrogen additions, NITRELMANG® is the ideal alloy for stainless and resulfurized grades of steel.

Whether you design the product or design the steel, Foote ELECTROMANGANESE® and NITRELMANG® are ready to serve you. If you want additional information, we'll be happy to help you.



### **FOOTE MINERAL COMPANY**

**424 Eighteen W. Chelton Building, Philadelphia 44, Pa.**

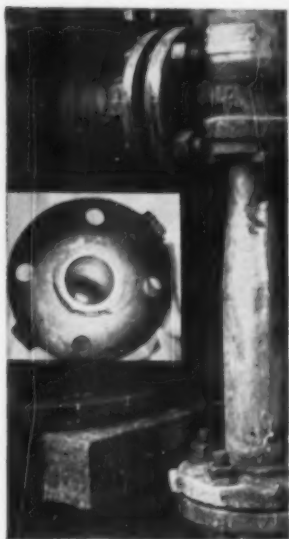
**RESEARCH LABORATORIES: Berwyn, Pa.**

**PLANTS: Exton, Pa.; Kings Mountain, N.C.; Knoxville, Tenn.; Sunbright, Va.**

MALLORY • SHARON

reports on

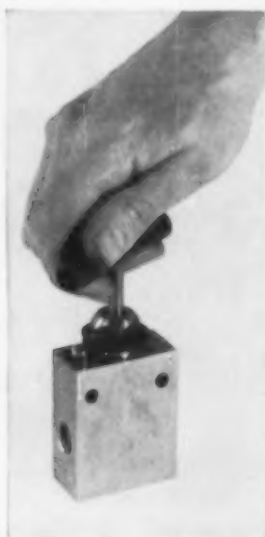
# TITANIUM



Titanium bore of steam jet ejector installed at DuPont shows no corrosion despite exposure to hydrochloric acid and high velocity steam. Previously, bore of different material had to be replaced frequently. Compare titanium bore to cast-iron flange.



Use of titanium in an anodizing rack has increased useful life from forty-five hours to one year. The sulphuric acid electrolyte used in anodizing operations quickly attacked the material previously used. Made by R. W. Renton Co.



Valve made of titanium for handling corrosive materials. Titanium is now much easier to fabricate than it was even a year ago. Thus piping, tubing, and complicated fittings are now available. Made by Autoclave Engineers, Inc.



Where use of Titanium piping is indicated, it can mean fewer shutdowns, contribute to safer operation. These Ladish Seamless Butt Welding Fittings, by Ladish Co., show versatility in fabrication of variety of fittings... elbow, tee, cap, and reducer.

## Where **TITANIUM** stops corrosion



### DESIGN AWAY CORROSION WITH TITANIUM

New booklet lists available data on titanium's corrosion-resistant properties, shows typical applications, and includes corrosion data charts covering behavior with many common acids and industrial chemicals. For free copy write Mallory-Sharon Titanium Corporation, Dept. T-10, Niles, Ohio.

• Titanium offers outstanding resistance to many common corrosive media, including some of the most troublesome industrial chemicals — nitric acid, moist chlorine, chlorinated organic or inorganic compounds, etc. Titanium is not susceptible to stress corrosion, and resists pitting attacks in solutions which affect other metals.

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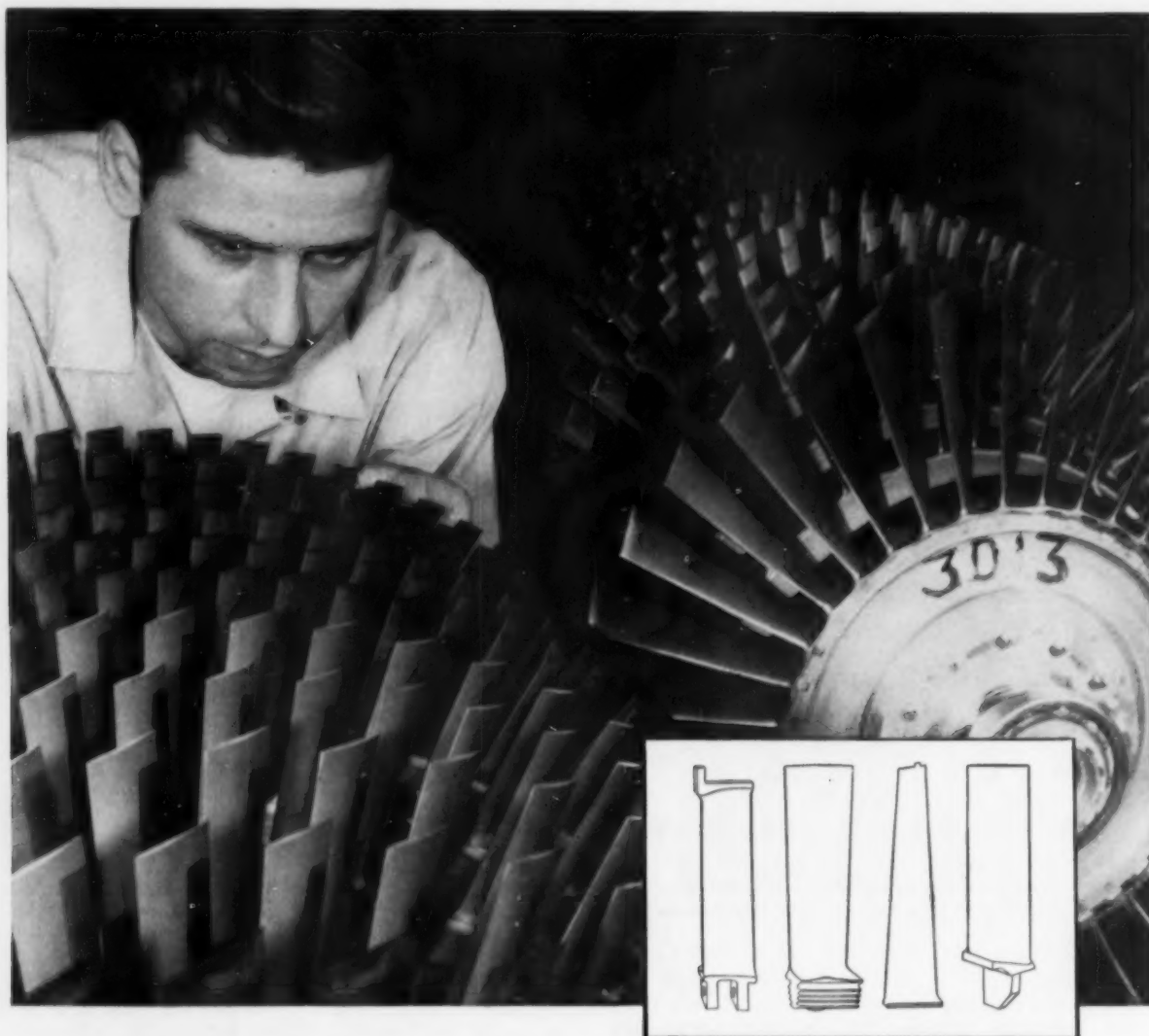


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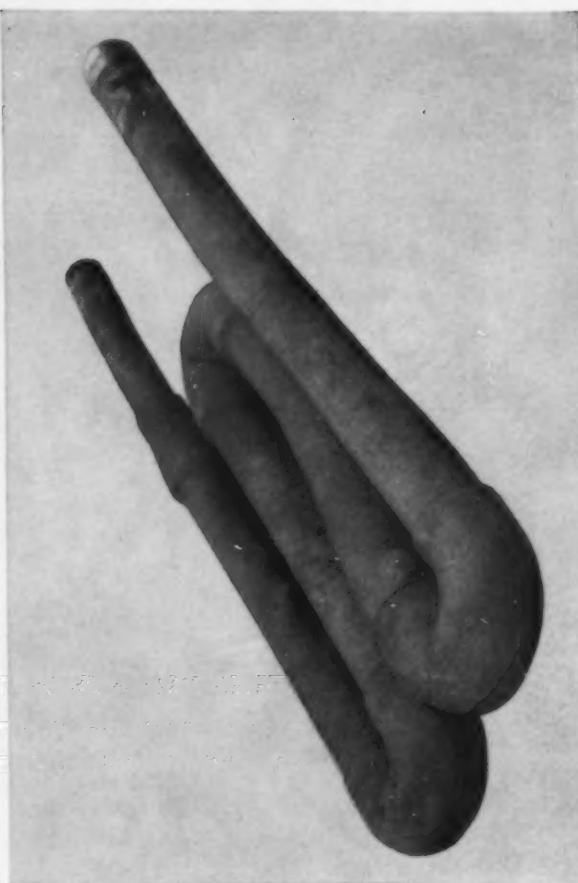
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**X-ite**



This unretouched photograph shows deterioration of 25-12 alloy radiant tube after 10 months service.



This unretouched photograph shows radiant tube of NA22H still in serviceable condition after 78 months service in the hot zone where temperatures averaged 1850°F.

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*Has provided five times longer service life for  
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After a total of 78 months service in temperatures

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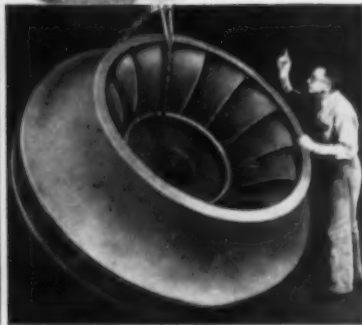
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D-53



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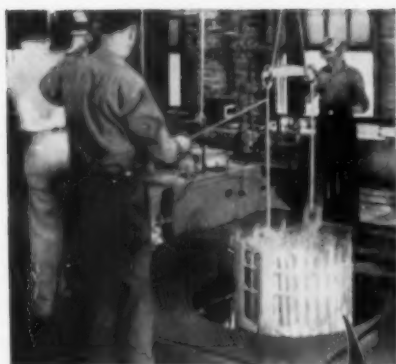
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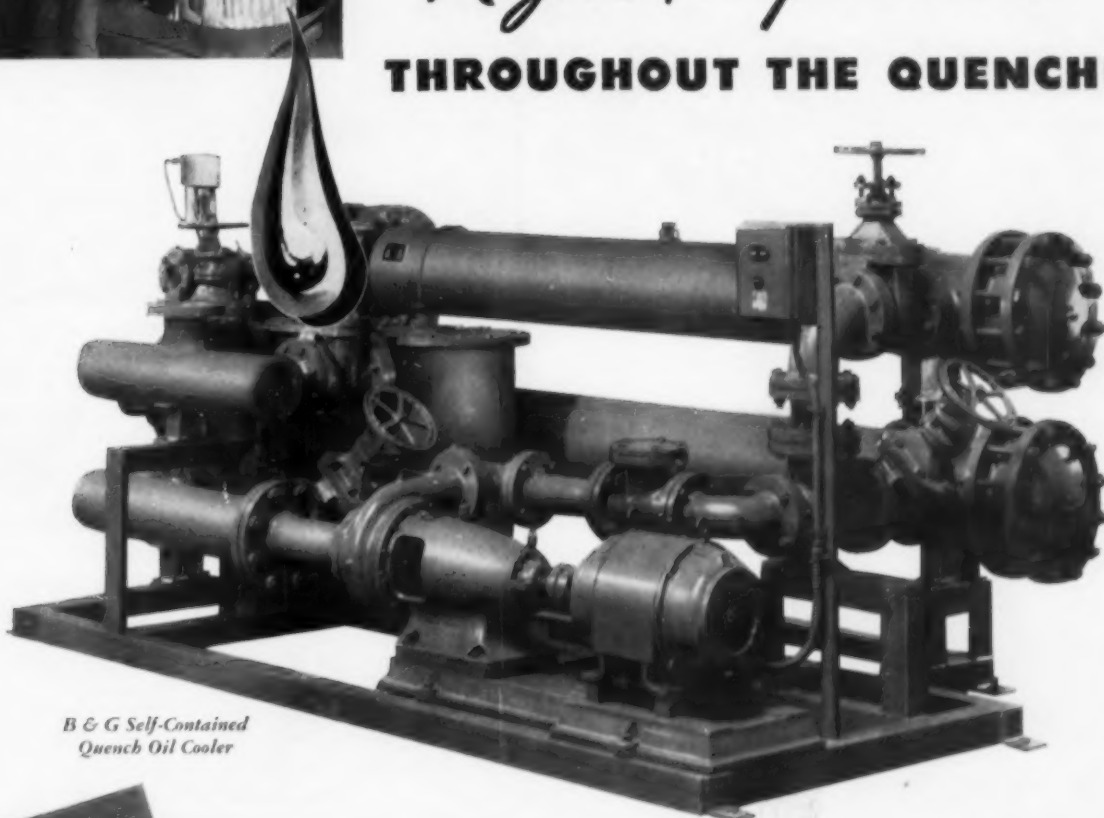
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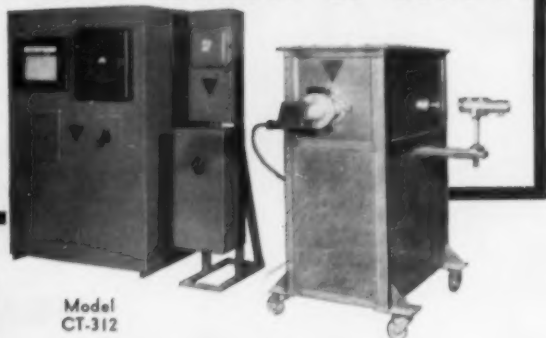
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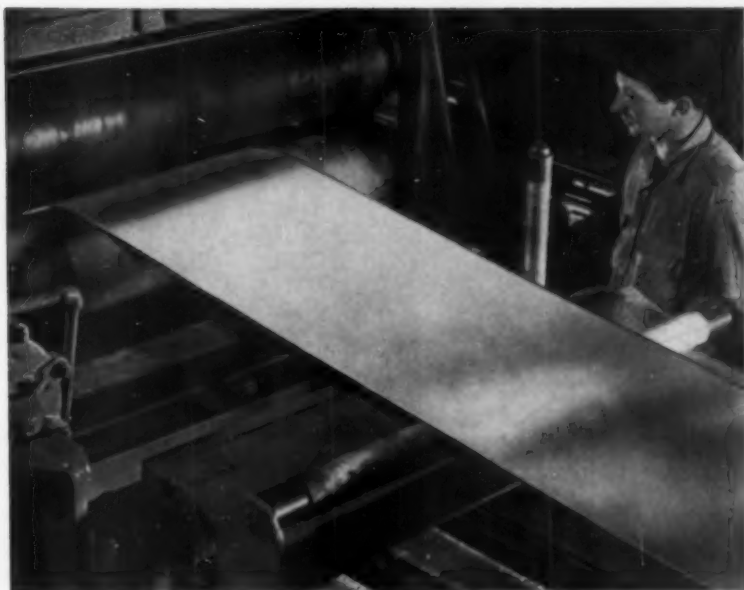
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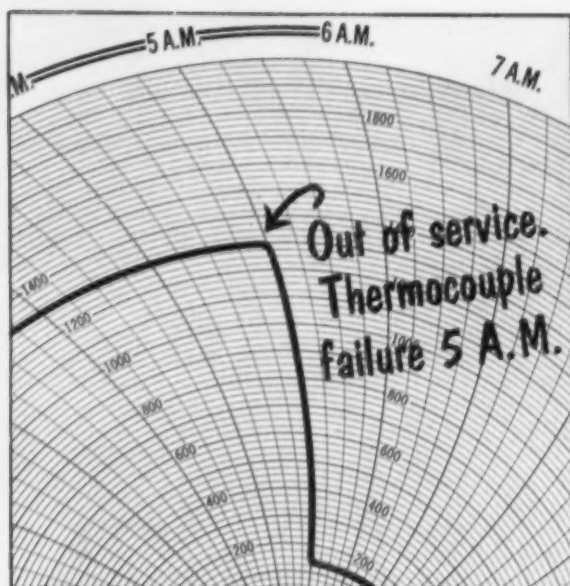
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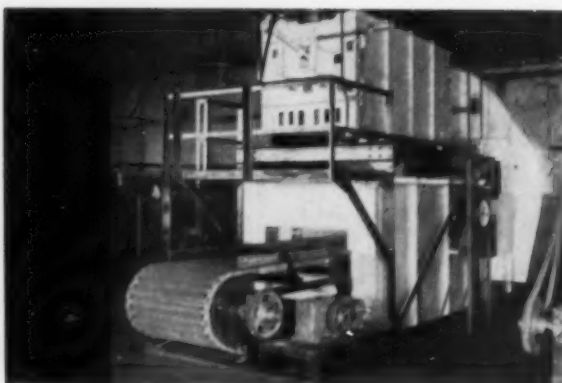
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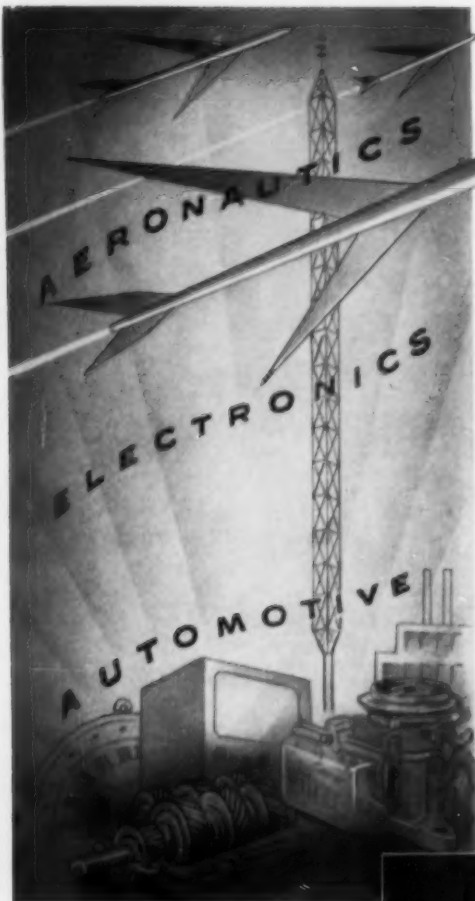
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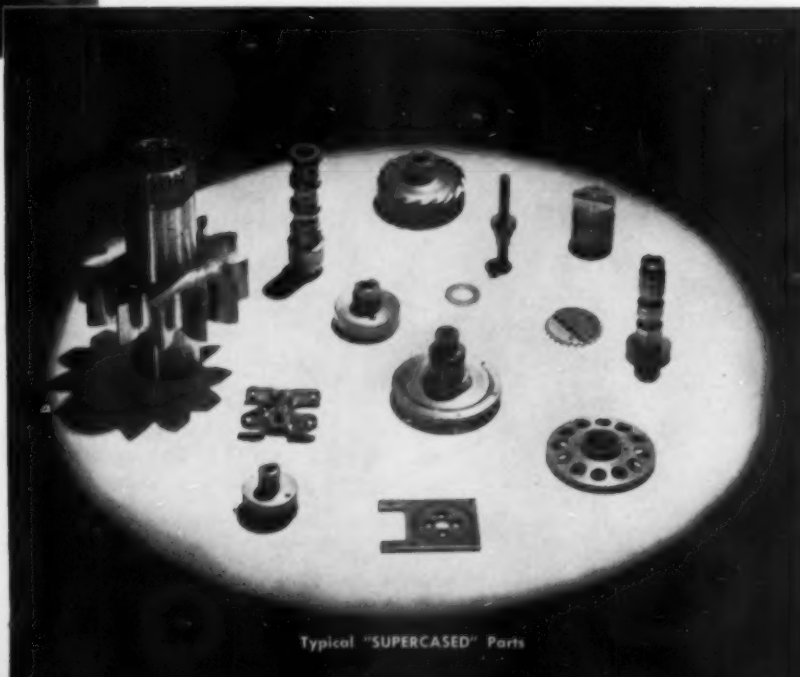
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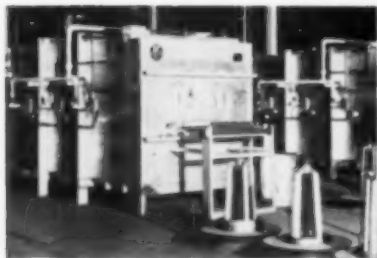
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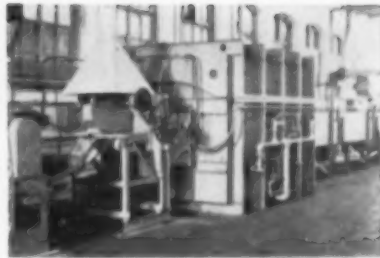




An EF multiple tube type furnace bright annealing stainless steel wire, continuously. One of an installation of five stainless steel furnaces we built in a prominent steel plant.



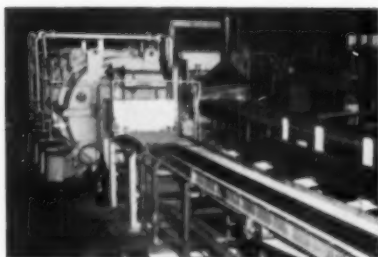
Large capacity EF gas fired furnace bright annealing stainless strip. We build them electrically heated or gas fired for wide or narrow strip, for single or multiple strands.



Stainless steel strip in various widths is bright annealed continuously in this EF gas fired special atmosphere installation equipped with an EF gas fired ammonia dissociator.

# Bright Annealing Stainless

## Tubing, Strip, Wire, Stampings and Other Stainless Steel Products



Stainless Steel Tubing in various diameters and lengths up to 24 feet is bright annealed continuously in this EF gas fired furnace.



Stainless Steel Strip. Wide, narrow and in various types, is uniformly bright annealed, continuously, in EF furnaces — any tonnage.

Stainless steel strip, wire, heavy and fine tubing, stampings, flatware, cooking ware, drawn and other stainless steel products, in many shapes and forms, are being bright annealed, uniformly, economically, continuously and with laboratory precision in EF furnaces of various sizes and types we have built.

Extensive experience with stainless steel problems, backed by over 40 years of practical furnace building experience and thousands of successful fuel fired and electric installations, enable EF engineers to design and build the best size and type of equipment needed for handling any product or production, or for any heat processing requirement.

Submit your production furnace problems to experienced EF engineers — it pays.



**THE ELECTRIC FURNACE CO.**

GAS FIRED OIL FIRED AND ELECTRIC FURNACES FOR ANY PROCESS, PRODUCT OR PRODUCTION

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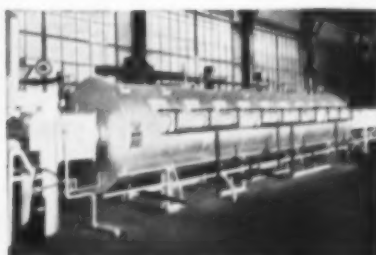
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Stainless Steel Wire is bright annealed in this and other EF continuous and batch type gas fired and electric furnaces we build.



Stainless Steel Stampings, flatware, drawn and other products; large, small and in various shapes are bright annealed in EF furnaces.



Another type we build for bright annealing stainless strip. This EF furnace also handles other grades requiring lower temperatures.



'dag' dispersions... *a touch does so much!*

After mold is machined, undiluted 'Prodag' is rubbed on the inside with a cloth.



Slick, non-porous surface of casting permits clean parting from mold and requires less finishing time.



## "Mold treatment with 'Prodag' for better products at low cost."

*says Wisconsin Centrifugal Foundry*

Wisconsin Centrifugal Foundry casts sleeve-type brass bearings in graphite molds. Castings range from 2 inches to 30 inches in diameter; pouring temperatures from 2,000 to 2,200°F. This company has found that a single application of undiluted 'Prodag', rubbed into the mold, lasts for entire production runs of certain items. Molten metal does not adhere to the inside surface, so castings part easily. Less time is required for finishing, so rejects are fewer. 'Prodag' helps Wisconsin Centrifugal turn out a better product at a lower cost.

'Prodag' and other Acheson dispersions have become indispensable for many foundry applications because of their remarkable properties under the most severe conditions. Acheson Service Engineers will be glad to give you specific information on the use of 'dag' dispersions for mold coatings, maintenance lubrication, and other applications. No obligation, of course.

For ready-to-use materials containing 'dag' dispersions see your own oil supplier, or write directly to us.



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